## Attività didattica programmata/prevista

## Insegnamenti

| n. | Denominazione dell'insegnamento | Numero di ore totali sull'intero ciclo | Distribuzione durante il ciclo di dottorato (anni in cui l'insegnamento è attivo) | Descrizione del corso | Eventuale curriculum di riferimento | Per i dottorati nazionali: percorso formativo di elevata qualificazione | Verifica finale | Note |
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| 1. | Plant genomics | 10 | first year | Docente: Dott.ssa Caterina Morcia<br><br>The course "Plant Genomics" will be held at the Centre for Genomics and Bioinformatics in Fiorenzuola d'Arda. It will consist of a series of seminars led by researchers from the Centre, each with different areas of expertise, and a section dedicated to visits to experimental fields and greenhouses. This short course aims to provide...<br><br>The course will provide insights into the role of genetics and genomics in agricultural practices that not only aim to ensure food security through increased production, but also assist farmers in protecting and conserving natural resources to meet the needs of future generations. Topics will cover both fundamental and applied plant genetics and genomics, including aspects related to both traditional and innovative genetic improvement of plants. | | | NO | Planned educational activity for the academic cycle, optional course. |
| 2. | From beer and bread to human disease and beyond: what yeast cells can teach us | 4 | First year | Docente: Dott.ssa Camilla Ceccatelli Berti<br>The course aims to analyse the contribution of the yeast model to research on human diseases and to present the main tools this model offers for the functional characterisation of variants in genes involved in Mendelian diseases, mitochondrial disorders, and cancer. Additionally, the use of yeast for the discovery of molecules with therapeutic activity will be explored in depth. | | | NO | Planned educational activity for the academic cycle, optional course |

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| 3. | The long and short of High-Throughput Sequencing: a practical approach | 10 | First year | Docente: Dott. Marco Morselli<br>The short course will present the following topics:<br>-high-throughput sequencing technologies: Next-Generation Sequencing, single-molecule real-time sequencing, and the newest platforms<br>-how to prepare an NGS library for DNA, RNA, and epigenomics<br>-single-cell sequencing (RNA, ATAC, multi-omics)<br>-spatial transcriptomics<br>This course will give students the basics to choose the best genomics approach for their experiments conducted during the doctorate, applicable to all fields of biological research. | | | NO | Planned educational activity for the academic cycle, optional course |
| 4. | Multivariate Statistics and Molecular Evolution | 6 | Second year | Docente: Prof. Angelo Pavesi<br>The course aims to explain the mathematical foundations of certain multivariate statistical methods, as well as their application in research topics covering the molecular evolution of microorganisms such as yeast, bacteria, and viruses. Multivariate statistics, introduced as an extension of univariate and bivariate statistics, involves the simultaneous use of multiple variables, made possible by matrix algebra and geometry operations, to describe a given biological phenomenon. The methods explained in the course include: i) Analysis of... | | | NO | Planned educational activity for the academic cycle, optional course |
| | | | | Principal Components; ii) Linear Discriminant Analysis and its extension to the quadratic function and the Mahalanobis generalized distance; iii) Multiple Linear and Logistic Regression. The applications cover topics in population genetics (principal components and genetic variability due to drift), molecular evolution in viruses (discrimination between overlapping and non-overlapping genes in viruses of eukaryotic organisms) and bacteria (identification of determinants of thermal stability in the enzyme glutamate dehydrogenase of thermophilic bacteria), and gene expression in *Saccharomyces cerevisiae* yeast (a multiple linear regression model between expression levels and sequence composition properties in protein-coding genes). | | | | |

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| 5. | Ancient DNA | 6 | Second year | Docente: Prof. Cristian Capelli The molecular analysis of fossil remains ("Ancient DNA") represents one of the research areas that has generated significant interest in recent years, not only among professionals in the field. The idea that the DNA of an organism from the past can be reconstructed undoubtedly has an allure that transcends the pages of scientific journals and easily captures the attention of the general public. In this course, we will explore what ancient DNA is and how biological material recovered from archaeological, historical, and museum remains is analysed. We will examine the limitations and potential of this approach, reviewing the events that have shaped its development, both positively and negatively. Finally, we will analyse some of the most significant results, focusing particularly on those most relevant for understanding the evolutionary history of our species, *Homo sapiens*. | | | NO | Planned educational activity for the academic cycle, optional course |
| 6. | Scientific and financial challenges in the discovery and development of new antibiotics | 10 | Third year | Docente: Dott. Stefano Donadio The increased incidence of antibiotic resistance among human and animal pathogens is threatening many of the advances that medicine has made, risking to send humanity back to the pre-antibiotic era. There is an urgent need to find new preventive and therapeutic measures to address this slow-moving crisis. However, the pharmaceutical industry has almost completely abandoned the research and development of new antibiotics, further exacerbating the problem. The short course will analyze the challenges associated with antibiotic discovery, from choice of the target to sources of chemical diversity to the approach to follow. It will also analyze the steps necessary to transform a molecule with antibacterial properties into a drug candidate for clinical studies. Finally, it will describe how the industry has dramatically changed over the past generation, leaving a number of gaps that are slowly being filled by public and private-public partnerships. | | | NO | Planned educational activity for the academic cycle, optional course |

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| 7. | Regression analysis: theoretical basis and applications | 6 | First year<br>Second year | Docente: Prof. Matteo Manfredini<br>The course will provide students with an overview of the theoretical foundations and fields of application of regression. Compared to traditional hypothesis testing, the analysis of relationships between variables is less emphasised in basic statistics courses, particularly in its more applied aspects. Therefore, this short course aims to bridge, at least partially, this gap.<br><br>Firstly, the theoretical and statistical foundations of regression analysis will be presented with the aim of promoting not only correct application but also a better understanding and interpretation of the outcomes and results of this methodology.<br><br>Secondly, the course will cover various regression models, with the intent of demonstrating the vast potential of this approach and the broad scope of its application. In this way, students will be guided towards a conscious and reasoned choice of the most appropriate type of regression for the specific analysis and available experimental data.. | | | NO | Planned educational activity for the academic cycle, optional course |
| 8. | Human Epigenome Structure and Gene Expression Modulation by 3D-Genome Chromatin Organizers | 6 | Third year | Docente: Prof. Roberto Ferrari<br>The way epigenetic regulates genome structure and expression to forge cell identity has always been a critical issue, particularly for understanding the molecular basis of diseases. The importance of proper three-dimensional folding of the human genome sets the basis for establishing appropriate pattern of gene expression revolved to coordinate establishment of cell fate and coordinated response to environmental stimuli. Identify the 3D-genome chromatin regulators and their roles becomes of extreme importance in many aspects of cell reprogramming and cell differentiation biology. Our lab is uncovering the role of unexpected new genome regulators formerly reported as ubiquitous general transcription factors. Characterization of these proteins unveils previously unreported ways of shaping the 3D-genome structure via epigenome remodeling, opening new avenues of therapeutic intervention for diseases involving alterations of proper genome folding. | | | NO | Planned educational activity for the academic cycle, optional course |

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| 9. | Plant phenotyping , a tool for breeding and precision agriculture | 4 | Second year | Docente: Dott.ssa Michela Janni<br>Climate change is severely hampering crop yield and farmers incomes. The development and selection of new varieties more adaptable to the ongoing climate change is crucial. Moreover the adoption of farm management to increase agricultural sustainability is mandatory to achieve this goal. Plant phenotyping is key to deciphering the mechanisms triggered by plants during stresses. Several tools can be adopted to perform plant phenotyping both in controlled conditions as in open fields . The course will cover basic knowledge on plant phenotyping with a focus on invivo sensors developed by CNR. | | | NO | Planned educational activity for the academic cycle, optional course |
| 10. | Metagenomic Analysis Applied to the Study of the Microbiota | 10 | First year | Docente: Dott. Gabriele Andrea Lugli<br>The doctoral course offers an in-depth understanding of the advanced methodologies used in the study of the human microbiota. In this course, doctoral students will explore several key techniques, including 16S microbial profiling, shotgun metagenomics, and metatranscriptomics. These methodologies enable the identification, characterisation, and quantification of microbial communities within the human microbiota.<br><br>In addition to the theoretical foundations, students will learn the technical details of DNA sequencing and how to interpret and analyse the resulting data.<br><br>Particular emphasis will be placed on the use of bioinformatic tools and best practices for data management. Beyond the technical aspects, the course will delve into the practical applications of microbiota research, with examples of studies in the human context.. | | | | Planned educational activity in another Doctoral programme, available for use |
| 11. | The Human Microbiota: Structure, Functionality, and Interaction Dynamics | 10 | First year | Docente: Prof. Leonardo Mancabelli<br>The course will introduce the concepts. | | | | Planned educational activity in another Doctoral programme, available for use |

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| | | | | The course will cover the fundamental aspects of the human microbiota, focusing on the characterisation of the different microbial communities that colonise various compartments of the human body. The composition and functionality of the microbiota in the skin, oral cavity, respiratory tract, gastrointestinal tract, and urogenital tract will be examined in detail. Special attention will be given to the interactions between the microbiota and the host, exploring the dynamics that influence health and well-being. | | | | |
| 12. | The Role of Epigenetics in Complex Diseases: Studies in Patients and Animal Models | 4 | Second year | Docente: Maria Carla Gerra The course aims to provide some basic knowledge of epigenetics and to illustrate two common approaches in the study of multifactorial pathological conditions: the search for biomarkers for diagnosis or prediction and the investigation of the underlying epigenetic mechanisms that may contribute to the development of such conditions. The differences, advantages, and disadvantages of candidate gene strategies versus genome-wide approaches will also be discussed. Finally, two case studies will be presented as examples of the application of these analyses in animal models and human subjects. | | | | |
| 13. | Practical NGS data analysis: from raw reads to visualization | 10 | Second year | Docente: Marco Morselli<br>The short course will teach how to analyze RNAseq data through the GalaxyProject GUI platform (no coding skills required!):<br>-description of the Galaxy Project platform<br>-raw data retrieval from public databases<br>-quality control and trimming<br>-alignment<br>-count matrix<br>-differential expression<br>-genome browser visualization<br>-generation of final figures: PCA, volcano plots, heatmaps, pathways, ..)<br>This course will give students the basics for analyzing NGS data produced in the lab or retrieved from public databases, focused on eukaryotic systems. | | | | |