Course Stucture Diagram a.a. 2026/2027 -- 6249-PHARMACEUTICAL AND INDUSTRIAL BIOTECHNOLOGY

First Year	Teaching Activity	Sector	Lectures (h)	Practical Activities (h)	Labs (h)	CFU/ECTS	Learning Outcomes
Gruppo: a - Mandatory Courses							
C8489 - 0 - Advanced Biochemistry and Genomics I.C.							
Modulo integrato: C8490 - Metabolic and Structural Biochemistry	BIO/10	21	12	26	6	The course aims to provide students with a thorough understanding of metabolic biochemistry, with particular emphasis on the main biosynthetic pathways, the structure of key enzymes involved, and their regulatory mechanisms. These topics will also be addressed from an applied perspective, with reference to the use of engineered cell models for the production of compounds of industrial or therapeutic interest. Upon completion of the course, students will be able to: - Analyze and discuss with advanced competence topics related to metabolic biochemistry, both theoretical and applied; - Critically understand the structure-function relationship of enzymes; - Use advanced molecular graphics programs to analyze protein structure, conformational changes induced by mutations or interactions with regulatory elements, and to get acquainted with the role of cofactors in enzymatic catalysis.
Modulo integrato: C8491 - Applied and Functional Genomics	BIO/11	28	0	26	6	Upon completion of the course, students will acquire the theoretical and practical foundations for independently conducting genomic analyses, specifically: i) reconstruction and characterization of eukaryotic and prokaryotic genomes; ii) reconstruction and analysis of transcriptomes; iii) identification of interactions between proteins, DNA, and RNA; iv) identification of epigenetic modifications; v) identification of regulatory modules; vi) identification of pathological variants for diagnosis and prognosis, and reconstruction of the molecular mechanisms of pathologies; vii) personalized intervention strategies based on an individual's genomic characteristics.
C8499 - 0 - Intellectual Property Management	ING-IND/35	42	0	0	6	By the end of the course, students will have acquired a thorough understanding of the main intellectual property rights and the main forms of intellectual property protection specific to the biotechnology and pharmaceutical sectors. Students will also acquire analytical knowledge of the costs and benefits of intellectual property and will be able to develop strategies for managing intellectual property rights. Furthermore, students will be able to advise public and private entities on how to protect their research results and how research activities should be organized to avoid infringing the intellectual property rights held by others.
Gruppo: b - First Option Group (min CFU/ECTS 12 - max CFU/ECTS 12) - Choose one group among 1.1 and 1.2							
Group 1.1							
C8494 - 0 - Genome Instability	BIO/11	21	12	26	6	Upon completion of the course, students will understand: i) the genetic and molecular mechanisms of DNA damage and repair, checkpoint activation, and genomic instability; ii) the functions of disease-relevant protein factors; iii) mutations and molecular defects that lead to the development of human diseases such as cancer, neurodegeneration, aging, and immunological disorders. Furthermore, students will be able to conduct experiments to assess genomic instability using various methodologies
C8495 - 0 - Model Organisms	BIO/18	35	0	13	6	At the end of the course, the student has in-depth knowledge of the experimental approaches used in genetic analysis aimed at the in vivo functional dissection of complex biological processes. In particular, the student is able to: - Analyze and expertly discuss experimental results obtained through genetic methods aimed at studying the function of genes involved in a biological process of interest using eukaryotic model organisms. - Propose genome-scale investigation strategies for the functional genetic dissection of complex biological processes applied to model organisms

Group 1.2						
C8496 - 0 - Mechanisms of Signaling and Molecular Interactions	BIO/10	28	0	26	6	Upon completion of the course, students will possess a solid understanding of the molecular mechanisms and structural and functional interactions that regulate intracellular signaling, processes essential for maintaining cellular homeostasis. They will also acquire skills in experimental methodologies for studying signaling processes, with a particular focus on the large-scale analysis of protein-protein interactions (PPIs), which represent the physical-functional basis of intracellular communication networks. Upon completion of the course, students: ii) understand the main cellular signaling pathways, their functional interconnections, and their regulatory mechanisms; ii) understand and are able to use computational resources and bioinformatics tools to analyze signaling pathways and molecular interaction networks; are skilled in identifying relevant molecular targets and understanding how they are regulated in different biological contexts, including major pathological states.
C8497 - 0 - RNA Biology and Riboregulation	BIO/11	21	12	26	6	Upon completion of the course, students will have acquired a thorough understanding of eukaryotic and prokaryotic mechanisms of RNA-mediated regulation, including RNAi, miRNA, piRNA, sRNA, ribonucleotides, and CRISPR. Students will be able to correctly understand the significance of new discoveries in these fields, evaluate their potential applications, and critically integrate this knowledge into a biotechnological context. Specifically, students will acquire expertise in gene regulation mechanisms mediated by noncoding RNAs, derived ablation strategies, and CRISPR-based methodologies.
Gruppo: c - Second Option Group (min CFU/ECTS 12 - max CFU/ECTS 12) - Choose two subgroups, one for each group (2.1 and 2.2)						
Group 2.1						
Subgroup 2.1.1						
93272 - 0 - ADVANCED IMMUNOLOGY	MED/04	42	0	0	6	At the end of the classes, the student will know about the cellular and molecular mechanisms that regulate the functioning of the immune system, how do they change in aging and diseases, as well as the main techniques to study them. The student will also know state-of-the-art possibilities to deploy immune activities for therapeutic purposes. In particular, the student will know about: i) the genetic strategies that allow the diversification of the immune responses to antigens; ii) the generation and use of monoclonal antibodies; iii) immunosuppression strategies; iv) generation of chimeric antigen receptors.
C8504 - 0 - Advances in Stem Cell Technology and 3D Organoid Systems	BIO/17	35	0	13	6	Upon completion of the course, students will be able to: understand the main molecular pathways that regulate stem cell stemness and differentiation potential; understand the fundamentals of innovation and development of three-dimensional (3D) culture systems, with particular reference to drug discovery and disease modeling; and apply methods for the in vitro preparation of advanced cellular models aimed at generating 3D spheroid/organoid cultures.
Subgroup 2.1.2						
C8508 - 0 - Protein Technologies: from Production to Characterization	CHIM/03	28	0	26	6	By the end of the course, students will have acquired a solid understanding of the main methods for protein production and purification, both from biological sources and recombinant expression systems. They will understand the chemical and physical principles underlying protein folding and stability and will be familiar with the experimental methods used to characterize these properties. Spectroscopic, calorimetric, and light scattering applications will be described as methods for studying protein folding, oligomeric state, conformational changes, and protein-protein or protein-ligand interactions (including drugs), all closely related to protein function. Students will learn to interpret data obtained from proteins in solution to derive biologically relevant information and evaluate their potential as drug targets. Specifically, by the end of the course, students will be able to: i) design experimental strategies to express and isolate proteins of interest in their native form; ii) apply spectroscopic techniques to study secondary and tertiary structure and conformational changes; iii) use light scattering techniques to assess the oligomeric state and hydrodynamic properties of proteins; iv) understand and apply methods to study protein-protein and protein-ligand interactions. During the laboratory activities, students will purify a recombinant protein and perform its folding and interaction analysis using the techniques covered in the course.

C8507 - 0 - Structural Determination and Computational Modelling of Biological Macromolecules	CHIM/03	28	0	26	6	Upon completion of the course, students will have acquired basic knowledge for determining the three-dimensional structure of biological macromolecules using X-ray crystallography, cryogenic electron microscopy (cryo-EM), and computational modeling. Specifically, students will develop an understanding of the theoretical and experimental principles of X-ray crystallography and cryo-EM applied to biomolecules (proteins and nucleic acids) through a combination of lectures and practical laboratory activities. Furthermore, students will acquire theoretical and practical skills in using computational chemistry methods to study the structure and dynamics of proteins and metalloproteins. Finally, students will be able to critically evaluate the suitability of these methods for structural analysis and will develop the critical skills necessary to analyze the scientific literature related to the study of models of biological macromolecules obtained through crystallographic, cryo-EM, and computational techniques.
Group 2.2						
Subgroup 2.2.1						
93308 - 0 - BIOSENSORS	CHIM/02	28	24	0	6	Upon completion of the course, students will understand: - the theoretical principles and applications of (nano)biosensors in the biotechnological and pharmaceutical fields; - the composition and operation of different types of optical biosensors, based on the type of components, the mechanisms of signal recognition and detection; - the principles and techniques for the construction of integrated analytical systems, cellular biosensors, nanobiosensors, and for in vitro and in vivo imaging; - the principles of physical chemistry and electrochemistry for the construction and use of electrochemical biosensors; - the composition and operation of different types of electrochemical biosensors, based on the type of transducer and the molecular recognition process.
C8510 - 0 - Safety and Quality of Biopharmaceutical Products (I.C.)						
Modulo integrato: 90912 - ANALYTICAL CHALLENGES IN THE BIOPHARMACEUTICAL FIELD	CHIM/08	21	0	0	3	At the end of the course the student: - has knowledge of the analytical approaches used for the characterization of biopharmaceutical products, and of the methodologies used for the assessment of safety; - knows the basics on the critical aspects for the quality control of biopharmaceutical products; - understands the problems related to the physico-chemical characterization of recombinant biological products; - has the knowledge to adequately address the problems related to quality, biosafety and microheterogeneity of biological and biothecnological products.
Modulo integrato: 90827 - SAFETY PHARMACOLOGY AND TOXICOLOGY OF BIOPHARMACEUTICALS	BIO/14	21	0	0	3	The course aims to provide students with a solid introduction to the fundamental analytical techniques for the quality control of biotechnological drugs, with a particular focus on chromatographic methodologies and mass spectrometry. The basic theoretical principles and key practical applications will be presented

						methodologies and mass spectrometry. The basic theoretical principles and key practical applications will be presented, highlighting the crucial role of these techniques in ensuring product quality and safety throughout the drug's life cycle. Through an integrated approach combining theory and case studies, the course aims to provide the foundation needed to recognize critical issues related to the characterization and stability of biologics. Particular attention will be paid to critical quality attributes, stability assessment, and the evolution of the biosimilar and biobetter landscape. Upon completion of the course, students will: - Understand the central role of quality control in ensuring the safety, efficacy, and quality of biotechnological drugs throughout the product's life cycle; - Has the tools to understand issues related to the quality, biosafety, and microheterogeneity of biological and biotechnological products, including their manufacturing process. - Has a basic understanding of the critical quality attributes (Critical Quality Attributes) relevant to biotechnological drugs, with reference to their impact on product safety and efficacy. - Has knowledge of the basic principles and operation of the main chromatographic techniques and the fundamentals of mass spectrometry and is able to integrate this knowledge to evaluate critical quality and stability attributes of biological drugs. - Has acquired the fundamental concepts related to the comparative studies required for the characterization of biosimilars and biobetters, understanding the analytical differences compared to originator drugs. Furthermore, the course aims to provide students with an overview of the discovery and development phases of a new biotechnological drug, with particular attention to safety aspects, the cellular and molecular mechanisms of toxicity of biotechnological drugs, and the systemic toxicity of biotechnological drugs in organs and systems.
Subgroup 2.2.2						
B5849 - 0 - COMPUTATIONAL DRUG DISCOVERY	CHIM/08	28	0	26	6	Upon completion of the course, students will acquire theoretical and practical knowledge of the main computational techniques used in drug discovery and development. Specifically, they will learn the fundamentals and applications of methods such as molecular docking, molecular dynamics, and the use of predictive models based on machine learning and artificial intelligence, as well as strategies for integrating them into the process of identifying and optimizing potential new drugs. Students will also be able to plan in silico studies, set up virtual experiments, and use specialized software tools, both open-source and commercial, to support the design and development of bioactive molecules for various pharmaceutical targets.
C8511 - 0 - Microbiotechnology, Nanobiotechnology and Nanomedicine	CHIM/06	35	0	13	6	Upon completion of the course, students should understand the fundamental principles of nanotechnology, microbiotechnology, and nanobiotechnology. They should be familiar with the fundamental principles and applications of nanomedicine. Specifically, they should be familiar with some of the distinctive behaviors at the nanoscale, the nanomaterials used for biological applications, the basic biological components at the nanoscale, and the principles that enable their use in nanotechnology applications. They should be familiar with examples of applications in nanobiotechnology/nanomedicine. Skills: Upon completion of the course, students should be able to understand the general concepts of the scientific literature on nanobiotechnology and nanomedicine and to understand and critically analyze the nanobiotechnological components of scientific works and industrial applications. At this point, they should be able to delve deeper into the topic of nanobiotechnology/nanomedicine through the scientific literature and other researchers. Students should be able to understand the nanometric aspects of biosensor applications, such as those presented in the Biosensors course of this master's degree program. Students should be able to exploit the concepts of micro/nanobiotechnology and nanomedicine in the design of projects/experiments and discuss their choices.
Subgroup 2.2.3						
C8512 - 0 - Advanced Enzymatic Biocatalysis and Sustainable Technologies	CHIM/06	28	12	13	6	Upon completion of the course, students will understand the mechanisms of enzymatic catalysis, immobilization techniques, and the stereochemical aspects of biocatalysis. They will be able to apply these skills to solving biotechnological problems and to the design and stereoselective synthesis of new molecules

						these skills to solving biotechnological problems and to the design and stereoselective synthesis of new molecules. Specifically, they will be able to: i) select biocatalysts for these syntheses based on criteria of economy, sustainability, and overall process cost-effectiveness; ii) identify potential critical aspects of the enzymatic process and propose solutions; iii) evaluate the feasibility of substituting biocatalytic methods for traditional synthesis technologies based on the principles of industrial process redevelopment. These skills are applicable to a variety of sectors, ranging from macroscale biomass production to energy production, the production of products for the pharmaceutical, food, and textile industries, and even the design of diagnostics tools.
82576 - 0 - PROTEIN ENGINEERING	CHIM/11	35	0	13	6	At the end of the course, the Student will be able to analyze the kinetics of enzyme-catalyzed reactions, and will be confident with the methodologies of enzyme engineering. In addition, the Student will be able to evaluate the feasibility of industrial processes relying on the use of natural or artificial enzymes.

Second Year	**Teaching Activity**	**Sector**	**Lectures (h)**	**Practical Activities (h)**	**Labs (h)**	**CFU/ECTS**	**Learning Outcomes**
Gruppo: d - Third Option Group (min CFU/ECTS 12 - max CFU/ECTS 12) - Choose one group among 3.1 and 3.2							
Group 3.1							
C8528 - 0 - Biological Drugs and Vaccines I.C.							
	Modulo integrato: C8529 - Pharmacotherapy of Biological Drugs and Innovative Therapeutics	BIO/14	28	0	26	6	Upon completion of the course, students: - possess the skills to use pharmacological methodologies to analyze biological or innovative drugs, having learned the mechanisms of action at the molecular and cellular levels and the pharmacotherapeutic profile; - understand and be able to apply analytical procedures for evaluating individual drug response in relation to individual genetic variants; - understand the pharmacotherapeutic profile of biological drugs; - know and be able to use cellular models for the analysis of biotechnological or innovative drugs.
	Modulo integrato: C8530 - Vaccines	MED/07	28	0	26	6	Upon completion of the course, students will possess advanced knowledge in the fields of virology and microbiology, with particular emphasis on the biological characteristics of infectious agents, the dynamics of infectious processes, and the rationale for developing antiviral and antimicrobial strategies, particularly for the development of innovative vaccines. Furthermore, students will possess laboratory knowledge and skills related to the technologies required for the design, development, and characterization of recombinant vaccines.
Group 3.2							
C8532 - 0 - Microbial and Biochemical Biotechnology I.C.							
	Modulo integrato: C8533 - Microbial Biotechnology	BIO/19	28	0	26	6	The course is designed to explore the theoretical foundations and application criteria underlying the exploitation of microbial systems in the production of compounds of economic interest, energy recovery and generation, waste treatment, and environmental detoxification. Microorganisms will be primarily analyzed as biological catalysts of specific biosynthetic and/or degradative reactions conducted both in confined environments (bioreactors) and in open settings, focusing on interventions aimed at controlling and optimizing the processes of interest.
	Modulo integrato: C8535 - Industrial Biochemistry	CHIM/11	28	0	26	6	The course's objective is to impart knowledge regarding the role of enzymes in various industrial sectors. The content taught will enable students to evaluate the opportunities and methods for producing and using enzymes in the preparation of consumer goods, in food processing, and in the valorization of agro-industrial waste.
Gruppo: e - Fourth Option Group (min CFU/ECTS 12 - max CFU/ECTS 12) - Choose one group among 4.1 and 4.2							
Group 4.1							

C8537 - 0 - Industrial Processes for Recombinant Drugs	CHIM/11	28	0	26	6	Upon completion of the course, students will possess a basic understanding of industrial processes using microorganisms to produce compounds of pharmaceutical interest. Specifically, students will be able to: - develop industrial production processes (batch, fed-batch, and continuous fermentations) for recombinant proteins; - develop screening programs for the identification of novel microbial metabolites of pharmaceutical interest; - develop strategies for improving production processes.
C8541 - 0 - Pharmaceutical Formulation and Regulatory Science	CHIM/09	35	0	13	6	Upon completion of the course, students will possess theoretical knowledge and practical skills related to pharmaceutical formulations for both conventional medicine and nanomedicine. Specifically, students will: - be able to describe the different types of formulations in terms of their physicochemical characteristics related to the route of administration; - understand strategies for improving the therapeutic efficacy of drugs by modifying their biodistribution, release, and permeability through biological barriers; - possess practical skills related to technological approaches for the production of pharmaceutical nanoformulations. Furthermore, upon completion of the course, students will: - understand the main relevant laws and regulations in the pharmaceutical and biotechnology fields regarding production, marketing, and patentability. They will understand the meaning of Regulatory Authority and Regulatory Procedure; - understand the different types of documentary research and be able to apply the acquired knowledge within a scientific research program.
Group 4.2						
C8542 - 0 - Bioreactors for Biotechnological Processes	ING-IND/25	35	12	0	6	The overall objective of the course is to present and discuss tools for understanding the performance of biochemical reactors and fermenters used in the biotechnology process industry. Both the principles of biochemical processes and simple methods for studying bioreactors are covered, providing the skills for quantitative, albeit simplified, predictions of their behavior. The ultimate goal is to provide students with the basic tools for making predictions about bioreactor performance.
C8543 - 0 - Principles of Biochemical Engineering	ING-IND/24	35	12	0	6	Upon completion of the course, students will understand the fundamentals of the physical, chemical, and biochemical phenomena that determine the behavior of industrial plants of major interest in the biotechnology sector. They will therefore be able to perform quantitative analysis of biotechnology/biopharmaceutical industry processes and interact with other professionals involved in the design and management of industrial processes. Specifically, students will be able to: - understand a process diagram for the production of a biotechnological product; - perform mass and energy balances; - understand the transport phenomena involved in the process.
Gruppo: f - Electives (min CFU/ECTS 9 - max CFU/ECTS 9) - *to be defined*						
Gruppo: g - Mandatory Italian Course						
C9092 - 0 - CULTURA ITALIANA		21	0	0	3	Students will get acquainted with different aspects of the italian culture, concerning both science and humanities. To this aim, Students will be engaged in appropriate seminars, workshops, and team work.
Gruppo: h - Internship (min CFU/ECTS 6 - max CFU/ECTS 6) - Choose one activity						
85319 - 0 - INTERNSHIP ABROAD		0	0	78	6	The student becomes familiar with the methods and scientific problems that he will have to face during the internship and is able to carry out scientific reporting on selected aspects of his experimental research activity.
37840 - 0 - INTERNSHIP LM		0	0	78	6	The student becomes familiar with the methods and scientific problems that he will have to face during the internship and is able to carry out scientific reporting on selected aspects of his experimental research activity.
Gruppo: i - Final Examination (min CFU/ECTS 24 - max CFU/ECTS 24) - Choose Final Examination						
B0677 - 0 - FINAL EXAMINATION LM		0	0	0	3	The student writes, presents and discusses an original document reporting the experimental results obtained during the internship/preparation of the final examination.

86295 - 0 - INTERNSHIP ABROAD FOR PREPARATION FOR THE FINAL EXAMINATION		0	0	273	21	The student performs experimental activities on an original research topic and is able to design and conduct scientific experiments, collect and process experimental data, critically evaluate the results obtained.
90377 - 0 - INTERNSHIP FOR PREPARATION FOR THE FINAL EXAMINATION		0	0	273	21	The student performs experimental activities on an original research topic and is able to design and conduct scientific experiments, collect and process experimental data, critically evaluate the results obtained.
90053 - 0 - PREPARATION FOR THE FINAL EXAMINATION ABROAD		0	0	273	21	The student performs experimental activities on an original research topic and is able to design and conduct scientific experiments, collect and process experimental data, critically evaluate the results obtained.