DESCRIPTIVE SHEET OF THE PHD PROGRAM

Course Name: PhD Program in “Biomedicine, Neuroscience, and Advanced Diagnostics”

Academic Year: 2024-25

Teaching Location: University of Palermo

Department: Department of Biomedicine, Neuroscience, and Advanced Diagnostics (BiND)

Description of the Educational and Research Project

The PhD program in “Biomedicine, Neuroscience, and Advanced Diagnostics” (BiND) at the University of Palermo has been active for four cycles (starting from the XXXV cycle). The PhD program in “Biomedicine and Neuroscience”, from which it derives, has been active for six cycles. Notably, the PhD program has been strengthened by an established partnership with the University of Texas Medical Branch (UTMB) in Galveston (USA) since 2012. For the XXXIX cycle, UTMB made available two additional scholarships for two foreign PhD students. In the last 10 cycles, UTMB has awarded a total of twelve scholarships to foreign PhD students without funding, who ranked high enough in the admission competition. Students enrolled at UTMB benefit from the status of “in-state students”; thus, they do not pay PhD program fees, do not pay “bench-fees,” are entitled to health insurance, and receive assistance with housing. All research costs for PhD students are covered by UTMB for the entire duration of their stay at the Texas campus. Students attend courses and earn credits both at the University of Palermo and at UTMB, both of which will be free of charge.

The BiND PhD program is structured in an interdisciplinary and multidisciplinary way, enabling students to promptly engage with key topics across the three curricula it encompasses: Biomedicine; Neuroscience; and Advanced Diagnostics. All three curricula address important and current issues in the fields of basic and applied research, which the scientific community recognizes as strategic for technological advancement.

Specifically:

- The Biomedicine curriculum aims to provide PhD students with the technical and scientific skills necessary to address the research topics within the field. These include various aspects of biological sciences, biotechnology, biomedical engineering, and clinical research in various areas (excluding neurological topics, which are covered in the Neuroscience curriculum). This training will enable students to address and solve scientific and practical problems, particularly regarding changes in cell differentiation, tissue homeostasis, and organ remodeling that lead to the onset of diseases.
- The Neuroscience curriculum includes specialized research topics in the main branches of neuroscience, particularly Neuroanatomy, Neurophysiology,

Neurosurgery, Cellular Neuroscience, Cognitive Neuroscience, Developmental Neuroscience, Computational Neuroscience, Evolutionary Neuroscience, Molecular Neuroscience, Neuroimaging, and Neuroinformatics. This curriculum is also partnered with the **Graduate School of Biomedical Sciences, Neuroscience Graduate Program, PhD in Neurobiology of Disease at the University of Texas Medical Branch** in Galveston, USA.

- Finally, the Advanced Diagnostics curriculum offers PhD students the opportunity to acquire specific technical and scientific expertise in advanced fields of radiological and biochemical diagnostics, such as machine learning, artificial intelligence, computerized analysis with "big data" techniques, digitization and networking of research laboratories, as well as next-generation biomarkers and advanced imaging techniques. Among the most significant and relevant of these, especially for its intersection with the Neuroscience curriculum, is neuroimaging and its innovative applications.

The training project is structured to provide students with the necessary elements for both personal and professional growth across a broad spectrum of topics related to biological sciences, biotechnology, biomedical engineering, clinical research, neuroscience, biomedical engineering in diagnostics, and advanced diagnostics.

International stays are mandatory; specifically, all students who apply to the international pathway must spend at least 18 months at UTMB, while all other students must spend at least 6 months at a foreign research institution. Educational activities will primarily be conducted in English. At the end of each year, students will be admitted to the following year based on an examination, and at the end of their studies, they will present their work in the form of a doctoral thesis in English. Students enrolled in the international program will take two exams, one at the University of Palermo and one at UTMB, and will receive two degrees as a result.

The acquisition of advanced scientific and technical knowledge and essential methodological tools for training highly specialized professionals capable of working in both public and private research institutions enables the following career prospects for PhD graduates in Biomedicine, Neuroscience, and Advanced Diagnostics, both in Italy and abroad: Academia, public or private research institutions, private high-tech companies in the fields of biomedicine, neuroscience, and advanced diagnostics, and public administration.

The ultimate goal is to train future PhD graduates in the principles of research in the biomedical, neuroscience, and advanced diagnostics fields, in the research sectors where the PhD faculty operate, providing all the necessary tools to pursue future activities in both scientific and technological research, as well as to enter professional roles in the economic and industrial sectors.

ACADEMIC OBJECTIVES

During the course, the students participate in educational activities, specifically designed for them and distinct from those offered in undergraduate and graduate degree programs. These activities also include attendance at specialized learning courses, participation in seminars, workshops, study days, or other courses offered by our University, including activities organized by the European Researchers' Charter Group of the University of Palermo.

In recent years, almost all of the specialized seminar activities in our PhD program have been delivered by highly qualified Italian or international experts from academia and research institutions.

The educational activities (see Attachment 1) provided in our PhD program are closely aligned with the research activities pursued in the three curricula. The goal is to train highly specialized researchers in the fields of biomedicine, neuroscience, and advanced diagnostics who can carry out their work at a national and international level as group leaders in public and private research institutions and in companies. Their training will provide them with skills to address and solve scientific and practical problems, particularly those related to changes in cell differentiation, tissue homeostasis, organ remodeling that lead to the onset of diseases, biomarkers, and advanced imaging techniques. The planning and organization document for the educational and research activities will be published on the PhD course website.

The curricula aim to specialize the research topics offered according to priority objectives that are consistent with the most advanced international research areas and those specific to the scientific disciplines of the professors affiliated with the PhD College.

Through experience in specialized laboratories, PhD students are provided with the tools necessary to develop innovative research projects. Moreover, they are encouraged to produce, where possible, interdisciplinary thesis work, often in collaboration with other institutions and on cross-cutting topics.

In addition to the specific training objectives of the PhD course, students will have access to common qualifying activities for all PhD courses, organized by the University of Palermo's Doctoral School, which is a member of the Council for Doctoral Education of the European University Association. In particular, the School promotes and coordinates the cross-disciplinary educational offerings, providing participants with interdisciplinary, multidisciplinary, and transdisciplinary training courses, as well as language and IT courses. It also offers activities in teaching, research management, understanding European and international research systems, promoting and disseminating research results, intellectual property, open access to research data and products, and the fundamental principles of ethics and integrity.

ACADEMIC ACTIVITIES

* All of the teachings below will be delivered in English and will be offered in a blended format (both in-person and online) to allow attendance (which is mandatory for all PhD students in the relevant years) even for students who are abroad for extended periods of stay.

n.	Course Name	Number of hours	Distribution throughout the PhD program	Course Description	Relevant Curriculum
1.	NEUROANATOMY	10	First Year	Students will acquire basic information about the development of the central and peripheral nervous system necessary to understand the pathophysiology of nervous system diseases from a cellular and molecular perspective and to design experimental plans on cellular and tissue models.	NEUROSCIENCE
2.	INFORMATION PROCESSING SYSTEMS	6	First Year	The course aims to provide basic knowledge related to Information and Communication Technology for the processing and analysis of medical data. It begins with an introduction to computer systems, followed by an overview of the structure and organization of both medical information systems and	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE

				clinical decision support systems.	
3.	NEUROPHYSIOLOGY AND NEUROPHARMACOLOGY	15	First Year	The educational objectives of the course are to provide students with theoretical and practical tools for: i) understanding and recognizing basic and higher neurophysiological functions; ii) acquiring practical skills related to laboratory techniques and neuroscience investigations; iii) identifying the etiopathological pathways involved in neurological disorders; iv) understanding the composition, properties, and actions of drugs used in the treatment of major neurological disorders.	NEUROSCIENCE
4.	HUMAN ANATOMY	20	First Year Second Year	Students will be able to: • Acquire basic knowledge of the human body to recognize an organ and identify its function and position. • Understand the technical foundations of Human Anatomy studies and its	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE

				modern applications in the biomedical field.	
5.	MEDICAL STATISTICS	10	Second Year	The course aims to provide the theoretical foundations to understand and describe different types of epidemiological studies, to equip students with the tools to understand and interpret the fundamental measures used in epidemiology, and to provide statistical knowledge and skills for data analysis applicable in scientific research in the human field.	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE
6.	ELECTRONIC MICROSCOPY	8	Second Year	The course will provide in-depth knowledge of the principles governing optical and electron microscopy, sample preparation, and the various operational modes available in the most modern instruments. Case studies will be presented, and practical sessions are included.	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE
7.	EXTRACELLULAR VESCICLES	10	Second Year	The course will provide students with an overview of extracellular vesicles, their functions, their subtypes, the methods used to isolate and characterize them, and the main pathological alterations	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE

				in which their etiopathogenetic role has been identified.	
8.	INNOVATION IN HEALTHCARE: TECHNOLOGY TRANSFER AND BIODESIGN	8	Second Year	This teaching focuses on 'needs-based innovation,' which has emerged in recent years as an alternative strategy for the development of medical products, particularly in the domain of biomedical technology (medical devices and diagnostics), placing a deep understanding of clinical needs at the starting point of the invention process	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE
9.	TARGETING EPIGENETIC MODULATORS IN CANCER AND NEURODEGENERATION	6	Second Year	The teaching will provide PhD students with an in-depth theoretical and practical understanding of the epigenetic mechanisms (such as DNA methylation and hydroxymethylation, post-translational modifications of histone tails, and nucleosome positioning) that regulate chromatin structure and gene expression levels without altering the primary DNA sequence, and how these influence carcinogenesis and neurodegenerative diseases	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE
10.	DATA SCIENCE AND BIG DATA ANALYTICS	10	Second Year	This teaching offers the students of our PhD program the opportunity to acquire the necessary knowledge related not only to data analysis but also to their management, from an analytical, computational,	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE

				and infrastructural perspective, so that they will be able to generate value from data management and analysis	
11.	NEUROSCIENCE OF HEARING AND BALANCE	10	Third Year	The course aims to provide an overview of the main neuroplastic phenomena resulting from auditory deprivation in both childhood and adulthood. A particular focus will be on the consequences of the loss of vestibular function. The phenomena of reorganization in the balance system and the adaptation mechanisms implemented by the central nervous system to reduce vertigo symptoms will be described. Finally, the neuroplasticity phenomena that enable the achievement of static and dynamic compensation will be discussed	NEUROSCIENCE
12.	MICROSCOPIC ANATOMY AND IMMUNOMORPHOLOGICAL TECHNIQUES	16	First Year	The objective of this course is to train PhD students in Biomedicine, Neuroscience, and Advanced Diagnostics on morphological and immuno-morphological techniques useful for studying the structural organization of tissues in the human body and laboratory animals (e.g., mice, rats). Regarding morphological techniques, the main histochemical stains (Hematoxylin and Eosin, Masson's Trichrome) will be performed on tissue samples	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE

				and then observed under an optical microscope, allowing the students, first and foremost, to properly use the instrument and recognize different tissue types and their organization within an organ. Among the immuno-morphological techniques, immunohistochemistry and immunofluorescence will be performed on tissue samples, followed by the observation of the preparations under both optical and confocal microscopes	
13	LABORATORY TECHNIQUES IN MAMMALIAN CELL BIOLOGY	10	First Year	The objective of this course is to teach PhD students the basic skills necessary to maintain and preserve cell cultures and the main molecular biology techniques. The lectures will cover the following topics: i) Control of cellular metabolism and growth through signaling pathways; Interactions between cells and their environments: general principles of signaling and cellular signal transduction; ii) Regulation of cell survival and proliferation in mammalian cells; iii) Main techniques for studying molecular biology (cell lysates, protein extraction, RNA extraction, isolation of extracellular vesicles); iv) Presentation of the cell cultures used in our laboratory and their characteristics.	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE

				The practical experiences will be as follows: 1) Good cell culture practices, including safety procedures, control of structures, equipment, and reagents; 2) Qualitative characteristics of mammalian cell cultures: counting and cell analysis; 3) Cryopreservation testing, cell banking, sterility, and microbial contamination; 4) Maintenance and manipulation of primary and immortalized cell lines under various experimental conditions; 5) Assessing the viability and proliferation of cells cultured under different experimental conditions using the MTT cell proliferation assay; 6) Western blot analysis; 7) RT-PCR analysis; 8) Ultracentrifugation and characterization of extracellular vesicles.	
14	FLOW CYTOMETRY AND ITS APPLICATION IN RESEARCH	10	First Year	The course aims to achieve the following objectives: i) knowledge of the principles underlying flow cytometry and the instrumentation; ii) reference points and guidelines for performing cytometric measurements; iii) learning the basic techniques; iv) in-depth exploration of some commonly used applications for studies in the biological and diagnostic fields; v) reading and interpretation of the results obtained.	BIOMEDICINE,ADVANCED DIAGNOSTICS NEUROSCIENCE

				Attendance and participation in the training activities (lectures and laboratory sessions) will enable students to acquire the necessary knowledge to address the different types and approaches that apply cytometric measurements in the biological field (evaluation of cell proliferation, cell cycle, and apoptosis) and diagnostic field (immunodeficiencies and oncohematological diseases). The teaching includes 5 hours of lectures delivered through multimedia presentations and presentation of cytometric files, and 5 hours of laboratory attendance.	
15	PSYCHOPHYSIOLOGY AND COGNITIVE NEUROSCIENCE	8	Second Year	Knowledge in Psychophysiology and Cognitive Neuroscience are closely dependent on the methodologies used to explore human brain functions. NIBS techniques (Non-Invasive Brain Stimulation) temporarily interfere with the underlying cortical areas, allowing for direct activation or modulation. Specifically, TMS (Transcranial Magnetic Stimulation) interferes with brain networks through electric currents induced by a strong magnetic pulse, while tDCS (Transcranial Direct Current Stimulation) induces a weak electric current	BIOMEDICINE, ADVANCED DIAGNOSTICS AND NEUROSCIENCE

sufficient to increase or decrease cortical excitability. fMRI (Functional Magnetic Resonance Imaging) can detect the BOLD signal, which is correlated with brain hemodynamic changes during a specific task. Embodied artificial intelligence in humanoid robots represents an intriguing new way of simulating the physiological functions of our brain, also modeling active perception and predictive coding. The course will cover the basics of these new technologies and the most up-to-date protocols, and will also illustrate the main clinical and therapeutic applications of NIBS (NIBS in clinical settings). Practical activities will be included to practice data management and analysis.