CSIC-UIMP Master on Molecular and Cellular Integrative Biology

MCIB II – October 2017 – March 2019 (90 ECTS)

The Master MCIB will provide an **advanced training in molecular and cellular life sciences to graduate students in a cutting-edge scientific environment**. The school, co-organized by the **Spanish National Research Council (CSIC)** and the **International University Menéndez Pelayo (UIMP)**, will focus on training the students in Molecular and Cellular Integrative Biology. MCIB integrates innovative experimental and/or computational technologies to characterize biological systems at the molecular, cellular, and tissue levels, in order to understand how component properties at one level in the dimensional scale (nano to macro) determine system behavior at a higher level of complexity. These integrated studies, with natural and minimal synthetic systems, will help to elucidate fundamental principles of biological function and provide a basis for novel biotechnological and biomedical applications.

MCIB is mostly organized at a single CSIC location (CIB), establishing a **unique -pioneer-in-house research training experience**. This novel concept will integrate both students and CSIC scientists as a collective action of the whole research center, bringing together a wide range of experimental expertise and know-how. Students will be exposed to the scientific activities developed in-house, based on synergies among research programs in molecular and cellular biosciences, using front-line technologies and research strategies (i.e., chemical, molecular/cellular and synthetic approaches) to study essential processes and systems with environmental or medical relevance.

MCIB is based on the **Max Planck International Research School for Molecular and Cellular Life Sciences** established at the Martinsried campus, which has been adapted and scaled to the Spanish research system.

1. Structure and Timing

The Master will run for 3 academic semesters starting in October until March of the second year. It comprises **90 ECTS credits**, organised in 3 different academic modules, a master research project and a final dissertation/exam.

MCIB will adopt an **innovative format** in which the students will progress rapidly from intensive course instruction to research in their master projects. Most of the MCIB activities will be in English, although Spanish will also be used, as required.

The program will begin with a **course semester** in which the students will be exposed to a broad spectrum of scientific questions and front-line technologies covering areas from fundamental (chemical, structural, molecular and cellular biology) and environmental biology to biomedicine.

Scientific training will be complemented by a variety of opportunities including lecture series, seminars, courses and participation in research conferences. In addition, a comprehensive **training program in transferable skills** will also be organized to prepare the graduate students for the challenges of a professional career in academia, industry or elsewhere.

This general interdisciplinary training will be combined with a **degree of specialization taking place at the supervisor's laboratory** of the master research project (TFM) – to be done during the second and third semesters, thereby providing both a broad and an in-depth training to the students.

2. Teaching program

Module I: Foundations of MCIB (30 ECTS; semester 1)

M1A. Research Topics and Programs in MCIB (15 ECTS)**:** Lecture series covering the following core research programs: Structural Molecular Biology, Biochemistry and Biophysics (SMB3); Cell Biology and Biomedicine (BIOMED): Molecular and Systems Biotechnology (BIOTEC)

M1B. Advanced Methods in MCIB (10 ECTS)**:** Introduction to state-of-the-art techniques and methods in MCIB

M1C: Laboratory Rotations (5 ECTS)**:** These rotations will help students to choose the laboratory where they will carry out their master research projects (TFM), during semesters 2 and 3.

Module II: Frontiers at MCIB (15 ECTS; semesters 1-3)

M2. Special Seminars and Workshops (15 ECTS)**:** The students will actively participate in a series of special seminars (five per semester) and workshops (one per semester) covering advanced topics in MCIB. The M2 faculty will consist of internationally recognized leading scientists.

Module III: Career Development & Technology Transfer Program (15 ECTS; semesters 1-3)

M3. MCIB EXTENSION (15 ECTS)**:** The students will be offered lectures and workshops covering a wide-range of research-related topics including scientific communication, quantitative reasoning, scientific writing, oral presentations, project managing, technology transfer, etc. They will provide a unique opportunity to acquire skills that are not routinely communicated in a laboratory environment.

Module IV: Master Research Project (TFM) (30 ECTS, semesters 2 and 3)

M4. Master Research Project (TFM) (30 ECTS)**:** The research project will be carried out along the 2nd and 3rd semesters of MCIB and will be supervised by a senior member of the corresponding laboratory together with the MCIB advisory committee.

FOR MORE INFORMATION ABOUT MCIB PLEASE READ THE DOCUMENT MCIB-brochure-2016.pdf

MCIB II – First semester: Teaching Program and Calendar (short version)

October - November 2017 – **SMB3: Structural Molecular Biology, Biochemistry and Biophysics**

M1A: SMB3 – FUNDAMENTALS / RESEARCH TOPICS

I. Structure, dynamics, molecular interactions and recognition of biological macromolecules: Introductory remarks: the flow of genetic information from chromosomal DNA to a natively folded protein. Biomolecular interactions: fundamentals; thermodynamics and kinetics; molecular recognition and ligand-receptor interactions. Biological macromolecules: a) nucleic acids; RNA-protein interactions and RNA metabolism; b) protein folding and stability; peptides; proteins and protein-protein interactions; intrinsically disordered proteins, amyloids**;** c) enzyme and catalysis; receptors**;** d) carbohydrates and protein-carbohydrate complexes**;** e) lipids and membranes: structural organization and dynamics. Macromolecular crowding.

II. Synthesis, modification and turnover of biological macromolecules: Synthesis, modification and turnover of proteins**.** Posttranslational modifications of proteins. DNA replication. Transcription: structural organization and regulatory mechanisms. DNA transposition and repair. Translation.

M1B: SMB3 – ADVANCED METHODS

I. Integrated structural biology and biophysics: 1) Biomolecular interactions - integrated biophysical analysis: analytical centrifugation, light scattering, calorimetry, spectroscopies, fluorescence-based and surface-sensitive assays, NMR. 2) Structural biology methods: NMR, macromolecular crystallography, (cryo)-electron microscopy.

Workshop on "Introduction to mathematical modeling using MATLAB: Application to the quantitative analysis of biomolecular binding equilibria and kinetics" (spring 2018).

II. Computational structural and chemical biology: Molecular modeling and simulation. Structural bioinformatics. Computational chemistry.

M1C: SMB3 – LAB ROTATIONS

M2 – MCIB FRONTIERS: Advanced seminars

The seminar program will be provided at the beginning of the academic course

M3 – MCIB EXTENSION:

Introduction to scientific writing and presentation: How to write and (critically) read a scientific manuscript**.** How to give an oral presentation and how to design a graphical abstract

December 2017 – **BIOTECH workshop + M2 / M3 activities**

M1: EXAM SMB3 (M1A – fundamentals; M1B – methods)

M2: MCIB FRONTIERS - Advanced seminars and workshop

M3: MCIB EXTENSION

M2 and M3 activities will be announced at the beginning of the academic year

January - February 2018 – **BIOMED: Cell Biology and Biomedicine**

M1A: BIOMED – FUNDAMENTALS & RESEARCH TOPICS

I. Internal organization of the cell: Intracellular membrane traffic. GTPases and intracellular organization. Cytoskeleton. Cell cycle. Autophagy; cell death and ageing. Bioenergetics: regulation of energy efficiency.

II. Cellular communities: Cell adhesion. Stem cells. Gametogenesis

III. Physiology and pathophysiology: Model systems in biomedicine. Cancer. Neurodegenerative diseases. Metabolic diseases

IV. Immunity and infection: Complement. Activation of T lymphocytes. Apoptosis and the immune system. Host-pathogen interactions.

V. Medicinal chemistry and drug design: Drug discovery. Rational (structure-based and ligand-based) drug design. Synthetic and combinatorial chemistry. Pharmaceutical chemistry: pro-drugs, bio-conjugation, drug delivery.

M1B: BIOMED – ADVANCED METHODS

I. Cell biology methods: Energetic metabolism. Flow cytometry. Immunofluorescence. Confocal microscopy. Time-resolved microscopy. Advanced fluorescence micro-spectroscopy. Isolation, identification and culture of adult stem cells

II. Medicinal chemistry and drug design methods: Spectroscopic assays for drug evaluation. Docking.

M1C: BIOMED – LAB ROTATIONS

M2: MCIB FRONTIERS - Advanced seminars and workshops

M3: MCIB EXTENSION

M2 and M3 activities will be announced at the beginning of the academic year

February - March 2018 – **BIOTEC: Molecular and Systems Biotechnology**

M1A: BIOTEC – FUNDAMENTALS & RESEARCH TOPICS

I. Environmental biotechnology, bioremediation and biodegradation: White Biotechnology: Bioengineering of plant biomass. Hydrolases and high redox- potential fungal peroxidases in lignocellulose processing. *Quorum sensing*: cellular communication in microorganisms

II. Synthetic microbiology and metabolic engineering: Metabolic engineering of systems for bioconversion of pollutants in bacteria. Enzyme engineering by direct evolution.

Synthetic biology: Engineering biological systems – bottom-up and top-down approaches. Bacteriophages and enzybiotics: alternatives to antibiotics

III. Bioreactors and applied microbiology: Biotechnological production of biologically-based polymers

IV. Applied plant biology: Biotechnology of plant cell reprogramming on earth and in the space

M1B: BIOTEC – ADVANCED METHODS

Protein biotechnology: Strategies for protein production and purification. Directed evolution of enzymes: practical session. Cell-free synthetic biology: Microfluidic-based formation of droplets and vesicles for encapsulation of biological macromolecules

M1C: BIOTEC – LAB ROTATIONS

M1: EXAMS BIOMED & BIOTEC (M1A – fundamentals; M1B – methods)

Second half February (BIOMED) and March (BIOTEC).

M2 – MCIB FRONTIERS – Advanced seminars and workshop

M3 – MCIB-EXTENSION

M2 and M3 activities will be announced at the beginning of the academic year