Master on Integrative Synthetic Biology

- The Master on Integrative Synthetic Biology (MISB) is a two-year (120 ECTS) advanced research school - co-organized by the UIMP and the CSIC - to provide graduate students (from life and physicochemical sciences to technology and engineering) with an **integrated program of training, research, and innovation on synthetic biology in a cutting-edge scientific environment**.

- The mission of MISB – the **first graduate school on synthetic biology in Spain** - is to prepare the next generation of synthetic biologists, which require novel ways of exploring living systems: **engineering to understand and master biological complexity**.

Synthetic biology is one of the most dynamic disciplines of life sciences, which introduces the **engineering perspective** to study biological processes, to **design and synthesize novel biological (or bio-inspired) systems that display valuable functions**, even those that do not exist in nature. In this line, the cell is like an intricate factory with devices and machines that carry out multiple tasks susceptible of being engineered to produce systems with **programmable functionality**.

Mastering the intrinsic capabilities of biological systems will contribute to **better understanding the basic principles of life** - and its emergence from lifeless components – and provide powerful tools for **novel solutions to outstanding environmental and health-related problems**.

- To achieve this challenge, MISB has adopted the format of the school it replaces - the master MCIB, organized by the same team during five editions - a **pioneer in-house research training experience at CSIC centers**, stem from the CIB Margarita Salas.

- MISB will be a **collective higher-education action of the leading CSIC centers on integrative synthetic biology**: the **CIB Margarita Salas** (the master's hub), the National Center of Biotechnology **(CNB),** and the Institute of Integrative and Systems Biology of Valencia **(I2SysBio)**.

- The training portfolio is fostered by the active participation of groups from other CSIC institutes, in particular the Institute of Physical Chemistry Rocasolano **(IQFR)**, the Institute of Catalysis and Petrochemistry **(ICP)** and the Institute of Biomedicine and Biotechnology of Cantabria **(IBBTEC)**.

- This novel training concept will expose the students to the scientific activities developed in these CSIC centers, bringing together a wide range of expertise and know-how of top research groups working on various disciplines of synthetic biology and related areas.

- They use **bottom-up, top-down and in silico approaches** with - artificial and natural - molecular and cellular systems to answer questions about the basic operating principles of life, and to provide solutions for global environmental or health challenges.

Top-down SynBio: aims to modify pre-existing cells to allow engineering genetic circuits, biological modules, and synthetic pathways to re-program organisms and produce pharmaceuticals, environmentally sustainable products, etc.

Bottom-up SynBio: aims to redesign and reconstruct biological parts, devices, and systems with increasing levels of complexity toward a minimal cell-like scaffold.

CSyCell – Constructing Synthetic Cells

Mastering the intrinsic capabilities of biological systems
- to understand basic principles of life and its emergence
- to provide novel solutions for environmental and health problems

From natural cells and minimal cell-like systems to synthetic cells

- ASSEMBLY – reconstitution of life-like molecular systems
- SYNTHESIS – integration of functional modules in natural and artificial cells
- TOOLS – enabling technologies (cell-free systems, microfluidics,…)
- BIOFACTORIES – next-generation platforms for green and health solutions
- SOCIETY – social perception, ethical implications, education, dissemination

SynBio approaches: top-down, bottom-up, *in silico*

SynCell Europe: MaxSynBio, BaSyC (NL), Max-Planck/Bristol-Minimal Biology, FABRICELL (UK), …

CSIC centers: CIB, CNB, I^{2}SysBio-Valencia, IBBTEC-Cantabria, CBMSO, CAB-INTA, ICP, IQFR, IFS-CCHS, Inst. Biofisika – Bilbao, …

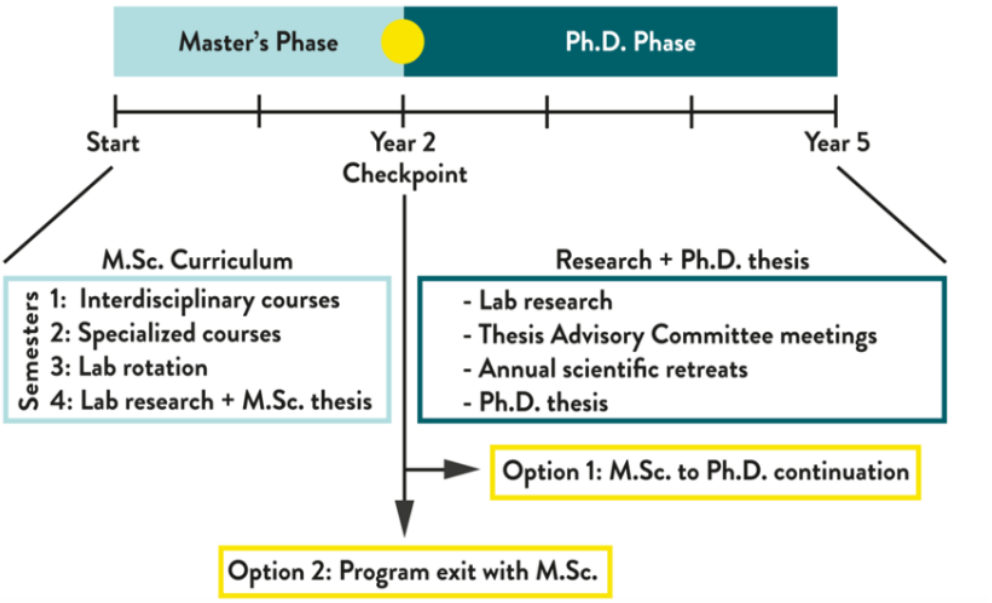
- MISB aims at fostering the assembly of an **intramural program (*CSyCell*)** to position the CSIC among the top European hubs on integrative synthetic biology research.

- These efforts are in line with several topics of the CSIC strategic plan and challenges for the next decades (i.e., Theme 2 - Origins, Co-Evolution, Diversity, and **Synthesis of Life** - of the White Paper CSIC Scientific Challenges 2030 – PTI CSyCell, PTI+ SusPlast)

- **The concept of the advanced schools of the Max Planck Society has inspired MISB's design** as one of the master's aims is to strengthen cooperative ties with the MP schools involved in integrative synthetic biology**.**

- MISB will build on the scientific and advanced training collaborations already consolidated, since the previously organized MCIB master, with the International **Max Planck Research School in Life Sciences (IMPRS-LS)** at the MP campus in Munich.

- The 120 ECTS scheme is a commitment to the **internationalization** plan of the program. The MISB format takes as a model the master's phase of the recently created **Max Planck School from Matter to Life** (master + Ph.D.)



MISB Program Structure and Timing

- MISB will run during **4 academic semesters**, starting in October until July of the second year.
- MISB will enroll **10-20 students** per promotion, to optimize the training process.
- It comprises **120 ECTS credits**, organized in **4 academic modules (90 ECTS)** and a **master research project TFM (30 ECTS)**.
- The 120 ECTS format aims to reinforce two of the training activities most in demand by students from the previous MCIB master: 1) the laboratory rotations and 2) the advanced lectures, courses, mini-workshops and transferable skills.
- MISB will adopt an **innovative format** in which the students will progress rapidly from intensive course instruction to extensive lab rotations and research (TFM) activities.
- Most of MISB activities will be in **English**.

M1. FUNDAMENTALS (25 ECTS, semester 1)

M1A – BASIC PRINCIPLES & RESEARCH TOPICS (15 ECTS, S1)

- I. ASSEMBLY - Reconstitution of life-like molecular systems:
- II. SYNTHESIS - Integration of functional modules in synthetic and natural cells:
- III. BIO-FACTORIES - Exploitation of SynBio in biotechnology and biomedicine:

M1B – ADVANCED METHODS (10 ECTS, S1)

- TOOLS

M2. FRONTIERS (30 ECTS, semesters 1-4)

M2A. FRONTIERS I (15 ECTS, S1-2)

M2B. FRONTIERS II (15 ECTS, S3-4)

Advanced seminars (8-10 per academic year) and **1-day workshops** (3-4 per academic year) to complement / reinforce topics covered in FUNDAMENTALS

M3. EXTENSION (10 ECTS, semesters 2-3)

M3A. EXTENSION I (5 ECTS, S2)

M3B. EXTENSION II (5 ECTS, S3)

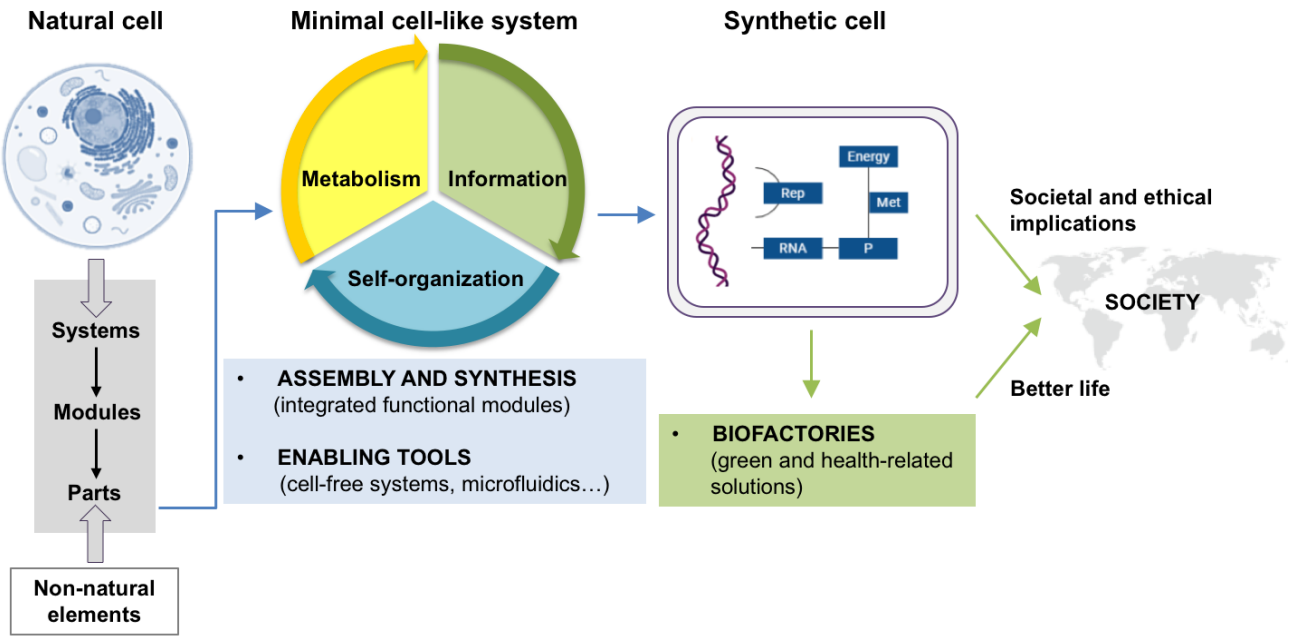
Seminars and workshops on **career development, professional and transferable skills, ethics**, etc.

M4. INTEGRATED LABS (25 ECTS, semesters 2-3)

M4A. INTEGRATED LAB I (15 ECTS, S2):

M4B. INTEGRATED LAB II (10 ECTS, S3):

Lab rotations, tutored research activities, introductory research project



M1. FUNDAMENTALS (25 ECTS, semester 1)

M1A – Basic principles and research topics (15 ECTS, semester 1)

- **I. ASSEMBLY - Reconstitution of life-like molecular systems**: Fundamental aspects of synthetic biology: engineering for understanding biological systems. Proto-cellular systems and origins of life. The macromolecules of life and their interactions. Molecular machines driving essential cell processes: information processing (replication, transcription and translation); growth and division; mobility and transport; energy transduction.
- **II. SYNTHESIS - Integration of functional modules in synthetic and natural cells:** Bottom-up approaches to assemble modules in cell-like compartments; mastering self-organization. Top-down approaches using engineered enzymes and microorganisms (natural cell containers with programmable functionality); engineered parts, modules, and circuits to master streamlined living cells/ organisms.
- **III. BIO-FACTORIES - Exploitation of SynBio in biotechnology and biomedicine**: Industrial biotechnology: engineering of biocatalysts for bio-transformations; bioremediation and biodegradation; directed evolution of enzymes. Metabolic engineering and synthetic microbiology. SynBio approaches to combat diseases: bacterial infections, protein-related pathologies (cancer, neurodegeneration, etc). Drug delivery systems – synthetic chemical biology.

M1B – Advanced methods (10 ECTS, semester 1)

- **TOOLS:** Integrated structural biology and biophysics. Molecular cell biology technologies. Advanced imaging tools. Nucleic acid and protein engineering. Protein biotechnology. Cell-free systems for bio-molecular production and functional assays. Compartments: generation and control using microfluidics. Molecular systems chemistry and engineering; drug design. In silico iSynBio: model-based bio-circuit design, simulation, optimization and control. Computational chemical biology

M2. FRONTIERS (30 ECTS, semesters 1-4)

M2A. FRONTIERS I (15 ECTS, S1-2)

M2B. FRONTIERS II (15 ECTS, S3-4)

- **Advanced seminars** (8-10 per academic year) and **1-day workshops** (3-4 per academic year) to complement / reinforce topics covered in FUNDAMENTALS

M3. EXTENSION (10 ECTS, semesters 2-3)

M3A. EXTENSION I (5 ECTS, S2)

M3B. EXTENSION I (5 ECTS, S3)

- **Seminars** and **workshops** on **career development, professional and transferable skills:** Communication skills – scientific writing and oral presentations; poster design, etc. Software-based workshops (statistics, MATLAB, imaging analysis, etc.). Project management: Research-development-innovation (R+D+i). Entrepreneurship and academia-business relations. Leadership, negotiation and team skills. Elaboration of a business proposal for an EBT (technology-based company), including technological, market and management aspects (groups of 3-4 students). Ethics and bioethics. Social Responsibility in Research. Leadership. Dissemination of science, etc. Elaboration of a prototype blog for scientific dissemination.

M4. INTEGRATED LABS (25 ECTS, semesters 2-3)

M4A. INTEGRATED LAB I (15 ECTS, S2)

M4B. INTEGRATED LAB II (10 ECTS, S3)

- Lab rotations, tutored research activities, introductory research project

M5. MASTER RESEARCH PROJECT – TFM (30 ECTS, semester 4)