



# Master on Integrative Synthetic Biology

Engineering Biomolecular and Cellular Systems

Academic Year 2024-2025

**COURSE 1 (MISB4) - SEMESTER 1 (10/2024 – 02/2025)**

**VERSION 19 NOV 2024**

## SEMESTER 1 (10/2024 – 02/2025)

### M1. FUNDAMENTALS (25 ECTS)

- 3 days of classes per week (Tues, Wed, Thu): up to 3 classes of 1 h (in the morning) + afternoon sessions (optional)
- Mon and Fri reserved for classes (if required), tutorials, journal clubs, **FRONTIERS**

**F0: FUNDAMENTALS 0.** Introductory sessions

**F1: FUNDAMENTALS 1.** Synthetic molecular cell biology – biomolecular and synthetic cell engineering

**F2: FUNDAMENTALS 2.** Synthetic and systems biotechnology

**EXAM F1** (31/10/2024 & 27/11/2024)

**EXAM F2** (22/01/2025 & 20/02/2025)

**M2. FRONTIERS I** (4-6 seminars & 1-2 workshops)

**26/02/2025: GRADE REPORTS SEMESTER 1**

## SEMESTER 2 (03/2025 – 06/2025)

**M2. FRONTIERS I** (4-6 seminars & 2 workshops)

**M3. EXTENSION I**

(Workshops lasting 1-3 days, preferable organized in the afternoon, to facilitate the attendance)

**M4. INTEGRATED LABS I**

(03-05/2025: 4-5 lab rotations; 06-07/2025: pending and extra lab rotations)

**28/06/2025: GRADE REPORTS SEMESTER**

## SEMESTER 1 (10/2024 – 02/2025)

### M1. FUNDAMENTALS (25 ECTS)

- 3 days of classes per week (Tues, Wed, Thu): up to 3 classes of 1 h (in the morning) + afternoon sessions (optional)
- Mon and Fri reserved for classes (if required) tutorials, journal clubs, **FRONTIERS** activities of the semester

### F0: FUNDAMENTALS 0. INTRODUCTORY SESSIONS

**F1: FUNDAMENTALS 1.** synthetic molecular cell biology - biomolecular and synthetic cell engineering

**F2: FUNDAMENTALS 2.** synthetic and systems biotechnology

**EXAM F1** (31/10/2024 & 27/11/2024)

**EXAM F2** (22/01/2025 & 20/02/2025)

**M2. FRONTIERS I** (4-6 seminars & 1-2 workshops)

**26/02/2025: GRADE REPORTS SEMESTER 1**

## OCTOBER 2024

Day	Hour	Lectures / Activities	Teacher	Room
01/10	11:00-13:00	MISB4 – welcoming	MISB academic board and coordinators	CIB (Hall)
<b>FUNDAMENTALS 0 – introductory lectures</b>				
02/10	09:30-11:00 11:30-13:00	Synthetic biology: a history of a yearny Synthetic biology: a diversity of approaches to master biological complexity	Juli Peretó (I2SysBio) Germán Rivas (CIB)	ONLINE CIB (Hall)
03/10	09:30-11:00	Chemical origins of life	Juli Peretó (I2SysBio)	ONLINE
04/10	11:00-12:00	<b>OPENING LECTURE - Rodrigo Ledesma (Imperial College London)</b> Synergies between synthetic biology and metabolic engineering for sustainable food production		ONLINE
<b>FUNDAMENTALS 0 – introductory lectures</b>				
07/10	10:00-11:00 11:00-12:00 12:00-13:00	<b>CHEMISTRY FOR SYNTHETIC BIOLOGY: BASICS</b> The chemistry of functional groups in molecules of biological interest. Conformation and tautomerism. Role in molecular recognition and biological function. Case studies. Chirality. Stereoisomerism. Shape. Case studies	Sonsoles Martín-Santamaría (CIB) Ruth Pérez (CIB)	CIB (-1)
<b>FUNDAMENTALS 1 – Synthetic molecular cell biology</b> <b>Basic principles and research topics.</b>				
08/10	10:00-11:00 11:30-13:00	<b>MOLECULES OF LIFE AND THEIR INTERACTIONS</b> Macromolecules and small molecules. Molecular recognition. Noncovalent interactions.	Sonsoles Martín-Santamaría (CIB) Sonsoles Martín-Santamaría (CIB)	CIB (-1) CIB (-1)
09/10	10:00-11:00 11:30-13:00	<b>FO:</b> Basis of the Chemical Biology Introduction to FUNDAMENTALS 1 Journal Club instructions	Ruth Pérez Germán Rivas	CIB (-1)
10/10	10:00-11:00 11:30-13:00	Molecular interactions: fundamentals of chemical equilibrium and kinetics Molecular interactions: introduction to binding analysis	Germán Rivas (CIB) Germán Rivas (CIB)	CIB (-1) CIB (-1)
11/10	10:30-13:00	<b>FO:</b> Revisiting basic calculus tools: Introduction to ODEs	Javier Buceta (I2SysBio)	ONLINE
14/10				
15/10	10:00-11:30 12:00-13:00	Lipids – essential concepts & assembly (membranes) Nucleic acids (natural and synthetic)	Iván López Montero (UCM) Carlos González (IQF)	CIB (-1) CIB (-1)
16/10	10:00-11:00 11:30-13:00	Carbohydrates – molecular recognition Bottom-up biology: a biophysical approach	Fco Javier Cañada (CIB) Iván López Montero (UCM)	CIB (-1) CIB (-1)
17/10	10:00-11:00 11:15-12:15	<b>ESSENTIAL CELLULAR PROCESSES</b> Information processing - replication Information processing – transcription	Rodrigo Bermejo (CIB) Carlos Fdez. Tornero (CIB)	CIB (-1) CIB (-1)
18/10				
21/10	10:00-11:00 11:30-12:30	Molecular interactions in the test tube and the living cell: implications for synthetic biology research. A. Macromolecular crowding B. Macromolecular phase separation	Germán Rivas (CIB)	CIB (-1)
22/10	10:00-12:00 12:30-13:30	Protein folding and assembly Protein modifications	Douglas Laurents (IQF) Dolores Pérez-Sala (CIB)	CIB (Hall)

23/10	10:00-11:00 11:30-12:30	Organization – cytoskeleton / cell division Organization – signaling and cell adhesion	Germán Rivas (CIB) Daniel Lietha (CIB)	CIB (-1) CIB (-1)
24/10	09:30-10:30 10:45-11:45 12:15-13:15	<b>Intracellular Traffic</b> General principles Molecular motors: Myosins, Kinesins, Dynein GTPases	Miguel A. Peñalva (CIB) Miguel A. Peñalva (CIB) Miguel A. Peñalva (CIB)	CIB (-1) CIB (-1) CIB (-1)
25/10	11:00-13:30	<b>MISB FRONTIERS – James Pelletier (CNB-CSIC)</b> Deciphering essential physiological processes in genomically minimal cells		CIB (Hall)
28/10				
29/10				
30/10				
31/10		<b>EXAM F1 (basic principles)</b>		

<b>NOVEMBER 2024</b>				
Day	Hour	Lectures / Activities	Teacher	Room
01/11		HOLIDAY		
<b>FUNDAMENTALS 1 – Synthetic molecular cell biology</b>				
Methods and tools				
04/11				
05/11	10:00-10:45 11:00-11:45 11:45-12:30 15:00-15:45	<b>PROTEIN PRODUCTION SESSION</b> Fundamentals of protein production tools. Membrane protein production. Antibody production in cell-free systems.  In vitro reconstitution of cell mimicking systems.	Cristina Vega (CIB) Daniel Lietha (CIB) Francisco J. Fernández (Abvance)  Cristina Fernández (I2SysBio)	CIB (-1) CIB (-1) CIB (-1)  ONLINE
06/11				
07/11	15:00-16:30	<b>MISB FRONTIERS - Kerstin Götpfrich (Heidelberg)</b> DNA nanotechnology and DNA origami for synthetic cells		ONLINE
08/11	10:00-10:45 11:00-11:30 11:30-12:00 12:30-13:00 13:00-13:30	<b>INTEGRATED STRUCTURAL BIOLOGY: NMR tools</b> NMR – fundamentals. NMR – Nucleic acids. NMR – Proteins. NMR – Protein supramolecular assemblies. NMR – Advanced NMR tools.	Francisco Blanco (CIB) Carlos González (IQF) José M. Pérez Cañadillas (IQF) Javier Oroz (IQF) Miguel Mompeán (IQF)	ONLINE IQF (215) IQF (215) IQF (215) IQF (215)

11/11	10:00-10:45 11:00-11:30 11:40-12:10 12:20-12:50  15:00-17:00	<b>INTEGRATED STRUCTURAL BIOLOGY: X-Ray crystallography tools</b> Fundamentals of X-ray Crystallography: from molecules to crystals and beyond. Membrane Maintenance at Contact Sites. Glyco-Synthetic Biology. Conformational Versatility in Protein Complexes.  Practical session: Crystallization, data collection and structure solution.	Juan A. Hermoso (IQF)  Armando Albert (IQF) Julia Sanz (IQF) Cristina Vega (CIB)  Lourdes Infantes, Beatriz González (IQF)	IQF (215)  IQF (215) IQF (215) IQF (215)  IQF (13)
12/11	10:00-11:00  11:15-12:15 12:30-13:30 15:30-16:30 16:30-17:00	<b>INTEGRATED STRUCTURAL BIOLOGY: Electron microscopy tools</b> Fundamentals: EM for the structural analysis of macromolecules EM – reconstructing cellular machines (1). EM – practical workshop EM – reconstructing cellular machines (2). EM – practical workshop.	Carlos Fdez Tornero (CIB)  Ernesto Arias (CIB) Rafael Nuñez, Begoña Pou (CIB) Javier Conesa (CNB) Javier Conesa (CNB)	CIB (-1)  CIB (-1) CIB (-1) CNB* CNB*
13/11	10:00-11:00 11:15-12:15 12:30-13:30  15:00-16:30	<b>MOLECULAR INTERACTIONS: Biophysical tools</b> AUC, light scattering. Calorimetry (ITC, DSC), circular dichroism. NMR- practical session  Molecular interactions – practical workshop.	Juan R Luque, Carlos Alfonso (CIB) Begoña Monterroso (IQF) FJ Cañada (CIB)  Juan R Luque, Carlos Alfonso (CIB)	CIB (-1) CIB (-1) CIB*  CIB*
14/11	10:00-11:00 11:15-12:15 12:30-13:30  15:30-17:30	<b>MOLECULAR INTERACTIONS: Computational tools</b> Fundamentals Applications Practical cases  <b>CHEMICAL BIOLOGY</b> Chemical biology tools – chemical systems and probes.	Sonsoles Martín-Santamaría (CIB) Sonsoles Martín-Santamaría (CIB) Sonsoles Martín-Santamaría (CIB)  Ruth Pérez (CIB)	CIB (-1) CIB (-1) CIB (-1)  CIB (-1)
15/11	11:00-12:30	<b>MISB-FRONTIERS – Christophe Danelon (Toulouse Inst. Biotech / TU Delft)</b> Constructing minimal cells that can evolve		ONLINE
18/11	10:00-13:00	<b>JOURNAL CLUB</b>		
19/11	10:00-12:00  12:15-14:15	<b>FLUORESCENCE / IMAGING</b> Fluorescence spectroscopy / microspectroscopy  Single-molecule and super-resolution imaging	Silvia Zorrilla (CIB)  Marcelo Nollmann (CBS Montpellier)	CIB (-1)  ONLINE
20/11	10:00-11:00 11:15-12:15 12:30-13:30	<b>MICROFLUIDICS in Synthetic Biology</b> Droplet microfluidics. Microfluidics – Practical session. Fluorescence – Practical session.	Begoña Monterroso (IQF) Begoña Monterroso (IQF) Silvia Zorrilla (CIB)	CIB (-1) CIB* CIB*
21/11				
22/11	11:00-12:30	<b>MISB FRONTIERS – Yuval Elani (Imperial College London)</b> Microfluidics & engineered biomembranes in synthetic cell design		ONLINE
25/11	9:30-14:00	<b>EXTENSION I-II: Taller de perspectiva de género en ciencia</b>	Eva Gálvez/Capitolina Díaz/Pilar Toboso	CIB
26/11				
27/11	10:00-12:00	<b>EXAM F1 (methods)</b>		
28/11				
29/11				

## DECEMBER 2024

Day	Hour	Lectures / Activities	Teacher	Room
<b>FUNDAMENTALS 2 – Synthetic and systems biotechnology</b>				
<b>Basic principles and research topics</b>				
02/12				
03/12	10:00-11:00 11:15-12:15 12:30-13:30	Therapeutic bacteria: from probiotics to synthetic biology Bacteria and immune system interface Amyloids as constructive parts in SynBio	Luis Ángel Fernandez (CNB) Esteban Veiga (CNB) Rafael Giraldo (CNB)	CNB CNB CNB
04/12	10:00-11:00 11:15-12:15 12:30-13:30	Optogenetics In vivo directed evolution of proteins Clocks and rules in life in the context of SynBio	Rafael Giraldo (CNB) Beatriz Álvarez (CNB) Saúl Ares (CNB)	CNB CNB CNB
06/12	<b>HOLIDAY</b>			
09/12				
10/12	10:00-11:00 11:15-12:15 12:30-13:30	Genome-Scale Metabolic Modeling The SEVA project as a standardization approach Large-scale and high-throughput genome editing	Juan Nogales (CNB) Esteban Martínez (CNB) Tomás Aparicio (CNB)	CNB CNB CNB
11/12	10:00-11:00 11:15-12:15 12:30-13:30	Biofactories based on synthetic bacterial compartmentalization High-throughput pathway assembly and optimization Assembling structured microbial ecosystems	Daniel López (CNB) Blas Blázquez (CNB) Esteban Martínez (CNB)	CNB CNB CNB
12/12	10:00-11:00 11:15-12:15 12:30-13:30	New tools to study plasmid-mediated antimicrobial resistance Enzymes for applications in health and sustainable chemistry Why integrate mimetic surfaces and some biophysical tools to study them	Álvaro San Millán (CNB) Francisco Plou (ICP) Marisela Vélez (ICP)	CNB ICP ICP
13/12				
16/12		<b>JOURNAL CLUB</b>		
17/12	10:00-11:00 11:15-12:15 12:30-13:30	Engineering cell factories for production of chemicals and fuels The revolution of directed evolution Visit EvoEnzyme	Eva García (ICP) Miguel Alcalde (ICP)	ICP ICP EvoEnz
18/12	10:00-11:00 11:15-12:15	Standards in synthetic biology Metabolic engineering of food-producing yeasts	Manel Porcar (I2SysBio) Agustín Aranda (I2SysBio)	ONLINE ONLINE
19/12				
20/12				
<b>HOLIDAYS: 23/12/2024 – 07/01/2025</b>				

## JANUARY 2025

Day	Hour	Lectures / Activities	Teacher	Room
<b>FUNDAMENTALS 2 – Synthetic and systems biotechnology</b>				
<b>Basic principles and research topics</b>				
07/01				
08/01	10:00-11:00	Enzyme biocatalysis for green chemistry: biotransformations mediated by microbial hydrolases	Alicia Prieto (CIB)	CIB (-1)
	11:15-12:15	Genome mining and rational design of new biocatalysts for lignocellulose biorefineries	Javier Ruiz-Dueñas (CIB)	CIB (-1)
	12:30-13:30	Evolution in the service of enzyme design	Susana Camarero (CIB)	CIB (-1)
09/01	10:00-11:00	Bacterial metabolic engineering for valorization of aromatic waste	Eduardo Díaz (CIB)	CIB (-1)
	11:15-12:15	Carbon dioxide and hydrogen as feedstock for bacteria	Gonzalo Durante (CIB)	CIB (-1)
	12:30-13:30	Metabolic engineering of yeast in waste revalorization	Carlos del Cerro (CIB)	CIB (-1)
10/01				
11/01				
12/01				
14/01	10:00-11:00	Biotechnology with metals: new challenges	Manuel Carmona (CIB)	CIB (-1)
	11:15-12:15	Nanotechnological tools: Dendrimeric and magnetic nanoparticles	Jesús Sanz (CIB)	CIB (-1)
	12:30-13:30	Lignin valorization into building blocks for bioplastics production	Helena Gómez (CIB)	CIB (-1)
15/01	10:00-11:00	Domesticating bacteria for tailored bioplastic production	Auxi Prieto (CIB)	CIB (-1)
	11:15-12:15	Engineering microbial cell factories by adaptive laboratory evolution	Isabel Pardo (CIB)	CIB (-1)
	12:30-13:30	Microbial cell to cell communication in biotechnology	Jorge Barriuso (CIB)	CIB (-1)
16/01				
17/01				
18/01				
19/01				
20/01	10:00-12:00	<b>EXAM F2 (basic principles)</b>		
<b>FUNDAMENTALS 2 – Synthetic and systems biotechnology</b>				
<b>Methods and tools</b>				
21/01	10:00-11:00	Biomolecular networks in synthetic biology (I) From gene regulatory networks to metabolic pathways. An introduction to biocircuits	Irene Otero-Muras (I2SysBio)	ONLINE
	11:15-12:15	(II) An introduction to dynamic modeling in systems and synthetic biology,		
	12:30-13:30	(III) Making a genetic toggle switch		
22/01	10:00-11:00	Practicum: Modeling Transcription and Translation (I)	Javier Buceta (I2SysBio)	ONLINE
	11:15-12:15	Practicum: Modeling Transcription and Translation (II)		
	12:30-13:30	Queueing: proteases and degradation as a tool in synthetic biology		
23/01				
24/01	10:00-12:00	<b>JOURNAL CLUB?</b>		
25/01				
26/01				
28/01	10:00-11:00	Biocircuits & functional motifs (I): Introduction, parts, systems and devices	Irene Otero-Muras (I2SysBio)	ONLINE
	11:15-12:15	(II): Automated design of biocircuits		
	12:30-13:30	(III): Optimization and control of biocircuits		
29/01	10:00-11:00	Biocircuits & functional motifs (IV): Feed-forward motifs	Javier Buceta (I2SysBio)	ONLINE
	11:15-12:15	(V): The role of noise		
	12:30-13:30	(VI): Multicellular Environments: QS and Tissues		
30/01				
31/01				

## FEBRUARY 2025

Day	Hour	Lectures / Activities	Teacher	Room
<b>FUNDAMENTALS 2 – Synthetic and systems biotechnology</b>				
<b>Methods and tools</b>				
03/02				
04/02	10:00-11:00 11:15-12:15 12:30-13:30	Examples of de novo RNA sequences with targeted function (riboregulators, de novo ribozymes, etc) Computational and experimental design of de novo RNA sequences with targeted function De novo virus design	Alfonso Jaramillo (I2SysBio)  Alfonso Jaramillo  Alfonso Jaramillo	ONLINE
05/02	10:00-11:00 11:15-12:15 12:30-13:30	Introduction to Metabolic Network Analysis Computational Protein Design Metabolic Pathway Design	Pablo Carbonell (I2SysBio) Pablo Carbonell Pablo Carbonell	ONLINE
06/02				
07/02				
10/02				
11/02	10:00-11:00 11:15-12:15	Sequence-based assignment of protein functional sites Analysis of biological networks: a complex-network approach	Florencio Pazos (CNB) Florencio Pazos (CNB)	CNB CNB
12/02	10:00-11:00 11:15-12:15	Bottom-up assembly of microbial ecosystem from metagenome data Synthetic communities-based biofactories	Javier Tamames (CNB)  Juan Nogales	CNB  CNB
13/02	10:00-11:00 11:15-12:15	Bacterial computing (I) Bacterial computing (II)	Ángel Goñi (CNB)	CNB
14/02				
17/02	11:00-12:30	<b>MISB FRONTIERS – Anke Becker (Center for Synthetic Microbiology, Marburg)</b> Title X		CIB
18/02				
19/02				
20/02	10:00-12:00	<b>EXAM F2 (methods)?</b>		
21/02	11:00-12:30	<b>MISB FRONTIERS – Tom Ellis (Imperial College London)</b> Title X		CIB
24/02				
25/02				
26/02		<b>GRADE REPORTS – SEMESTER 1</b>		
27/02				
28/02				
03/03	11:00-12:30	<b>MISB FRONTIERS – José Jiménez (Imperial College London)</b> Title X		CIB