Master on Integrative Synthetic Biology

Engineering Molecular and Cellular Systems
Academic Year 2023-2024
COURSE 1 (MISB3) - SEMESTER 1 (10/2023 – 02/2024)
VERSION 08NOV23

SEMESTER 1 (10/2023 – 02/2024)

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. Mechanistic synthetic biology
F2: FUNDAMENTALS 2. Synthetic and systems biotechnology

EXAM F1 (06 & 29/11/2023)
EXAM F2 (22/01/2024 & 22/02/2024)

M2. FRONTIERS I (4-6 seminars & 1-2 workshops)
29/02/2024: GRADE REPORTS SEMESTER 1

SEMESTER 2 (03/2024 – 06/2024)

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
(03-05/2024: 4-5 lab rotations; 06-07/2024: pending and extra lab rotations)

28/06/2024: GRADE REPORTS SEMESTER

SEMESTER 1 (10/2023 – 02/2024)

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. Mechanistic synthetic biology
F2: FUNDAMENTALS 2. Synthetic systems biotechnology

EXAM F1 (06 & 29/11/2023)
EXAM F2 (22/01/2024 & 22/02/2024)

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

29/02/2024: GRADE REPORTS SEMESTER 1

OCTOBER 2023				
Day	**Hour**	**Lectures / Activities**	**Teacher**	**Room**
02/10	11:00-13:00	MISB3 – welcoming	MISB academic board and coordinators	CIB (Hall)
FUNDAMENTALS 0 – introductory lectures				
03/10	11:30-13:00 15:00-16:00	Synthetic biology: an overview Integrated structural biology: an overview	Germán Rivas (CIB) Carlos Fdez. Tornero (CIB)	CIB (Hall)
04/10	10:30-13:00	Revisiting basic calculus tools: Introduction to ODEs	Javier Buceta (I2SysBio)	ONLINE
05/10	 10:00-11:00 11:00-12:00 12:00-13:00	CHEMISTRY FOR SYNTHETIC BIOLOGY: BASICS 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 (Hall)
06/10	11:00-12:00	**OPENING LECTURE:** What is life? How to approach an ancient question with cutting-edge research	**Petra SCHWILLE** (MPI Biochemistry, Martinsried)	ONLINE
FUNDAMENTALS 1 – Mechanistic synthetic biology Basic principles and research topics.				
09/10	10:00-11:00 11:30-12:30	Introduction to FUNDAMENTALS 1. Chemical origins of life	Germán Rivas (CIB) Juli Peretó (I2SysBio)	CIB (-1) CIB (-1)
10/10	 10:00-11:00 11:30-13:00	**MOLECULES OF LIFE AND THEIR INTERACTIONS** Macromolecules and small molecules. Molecular recognition. Noncovalent interactions.	 Sonsoles Martín-Santamaría (CIB) Sonsoles Martín-Santamaría (CIB)	 CIB (-1) CIB (-1)
11/10	10:00-11:00 11:15-12:15 12:30-13:00	Basis of the Chemical Biology Molecular interactions in the test tube and the living cell: implications for synthetic biology research. Journal Club instructions	Ruth Pérez (CIB) Germán Rivas (CIB) Germán Rivas (CIB)	CIB (-1) CIB (-1) CIB (-1)
12/10	HOLIDAY			
13/10				
16/10				
17/10	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)
18/10	10:00-11:30 12:00-13:30	Carbohydrates – molecular recognition Bottom-up biology: a biophysical approach	Fco Javier Cañada (CIB) Iván López Montero (UCM)	CIB (-1) CIB (-1)
19/10	 10:00-11:00 11:15-12:15 12:30-13:30	**ESSENTIAL CELLULAR PROCESSES** Information processing - replication Information processing – transcription	 Rodrigo Bermejo (CIB) Carlos Fdez. Tornero (CIB)	 CIB (-1) CIB (-1)
20/10	12:00-13:00	**MISB-FRONTIERS:** Designing biomimetic systems: from understanding biological self-organization towards synthetic cells	**Siddhart DESHPANDE** (Univ. Wageningen, NL)	CIB (Hall)
23/10				
24/10	10:00-12:00 12:30-13:30	Protein folding and assembly Protein modifications	Douglas Laurents (IQF) Dolores Pérez-Sala (CIB)	CIB (Hall)
25/10	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)
26/10	 09:30-10:30 10:45-11:45 12:15-13:15	**Intracellular Traffic** 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)

27/10				
30/10				
31/10	10:00-13:00	**JOURNAL CLUB**		

NOVEMBER 2023				
Day	**Hour**	**Lectures / Activities**	**Teacher**	**Room**
01/11	HOLIDAY			
02/11				
03/11				
FUNDAMENTALS 1 – Mechanistic synthetic biology Methods and tools				
06/11	10:00-12:00	**EXAM F1 (basic principles)**		
07/11		**PROTEIN PRODUCTION SESSION**		
	10:00-10:45	Fundamentals of protein production tools.	Cristina Vega (CIB)	CIB (-1)
	11:00-11:45	Membrane protein production.	Daniel Lietha (CIB)	CIB (-1)
	11:45-12:30	Antibody production in cell-free systems.	Francisco J. Fernández (Abvance)	CIB (-1)
	15:00-15:45	In vitro reconstitution of cell mimicking systems.	Cristina Fernández (I2SysBio)	ONLINE
08/11		**INTEGRATED STRUCTURAL BIOLOGY:** **X-Ray crystallography tools**		
	10:00-10:45	Fundamentals of X-ray Crystallography: from molecules to crystals and beyond.	Juan A. Hermoso (IQF)	IQF
	11:00-11:30	Membrane Maintenance at Contact Sites.	Armando Albert (IQF)	IQF
	11:30-12:00	Energy-conserving electron bifurcation	José M. Mancheño (IQF)	IQF
	12:30-13:00	Glyco-Synthetic Biology.	Julia Sanz (IQF)	IQF
	13:00-13:30	Conformational Versatility in Protein Complexes.	Cristina Vega (CIB)	IQF
	15:00-17:00	Practical session: Crystallization, data collection and structure solution.	Lourdes Infantes, Beatriz González (IQF)	IQF
09/11	HOLIDAY			
10/11				
13/11				
14/11		**INTEGRATED STRUCTURAL BIOLOGY: NMR tools**		
	10:00-10:45	NMR – fundamentals.	Francisco Blanco (CIB)	ONLINE
	11:00-11:30	NMR – Nucleic acids.	Carlos González (IQF)	IQF
	11:30-12:00	NMR – Proteins.	José M. Pérez Cañadillas (IQF)	IQF
	12:30-13:00	NMR – Protein supramolecular assemblies.	Javier Oroz (IQF)	IQF
	13:00-13:30	NMR – Advanced NMR tools.	Miguel Mompeán (IQF)	IQF
	16:0017:00	NMR – practical session.	Javier Cañada (CIB)	CIB*

15/11		**INTEGRATED STRUCTURAL BIOLOGY:** **Electron microscopy tools**		
	10:00-11:00	Fundamentals: EM for the structural analysis of macromolecules	Carlos Fdez Tornero (CIB)	CIB (-1)
	11:15-12:15	EM – reconstructing cellular machines (1).	Ernesto Arias (CIB)	CIB (-1)
	15:30-16:30	EM – reconstructing cellular machines (2).	Javier Conesa (CNB)	CNB*
	16:30-17:00	EM – practical workshop.	Javier Conesa (CNB)	CNB*
16/11				
17/11				
20/11		**INTEGRATED STRUCTURAL BIOLOGY: EM tools**		
	10:00-11:00	EM – practical workshop.	Fernando Escolar, Rafael Núñez (CIB)	CIB*
		MOLECULAR INTERACTIONS: Computational tools		
	11:15-12:15	Fundamentals	Sonsoles Martín-Santamaría (CIB)	CIB (-1)
	12:15-13:15	Applications	Sonsoles Martín-Santamaría (CIB)	CIB (-1)
	13:15-14:15	Practical cases	Sonsoles Martín-Santamaría (CIB)	CIB (-1)
		CHEMICAL BIOLOGY		
	15:45-17:45	Chemical biology tools – chemical systems and probes.	Ruth Pérez (CIB)	CIB (-1)
21/11		**MOLECULAR INTERACTIONS: Biophysical tools**		
	10:00-11:00	AUC, light scattering.	Juan Luque, Carlos Alfonso (CIB)	CIB (-1)
	11:15-12:15	Fluorescence spectroscopy.	Silvia Zorrilla (CIB)	CIB (-1)
	12:30-13:30	Calorimetry (ITC, DSC), circular dichroism.	Begoña Monterroso (CIB)	CIB (-1)
	15:00-16:30	Molecular interactions – practical workshop.	Juan Luque, Carlos Alfonso (CIB)	CIB*
22/11		**IMAGING (1)**		
	10:00-12:00	Confocal and multi-D microscopy.	Miguel A. Peñalva (CIB)	CIB (-1)
		IMAGING (2)		
	15:00-17:00	Single-molecule and super-resolution tools.	Marcelo Nollmann (CBS Montpellier)	ONLINE
23/11		**MICROFLUIDICS in Synthetic Biology**		
	10:00-11:00	Droplet microfluidics.	Begoña Monterroso (CIB)	CIB (-1)
	11:15-12:15	Microfluidics – Practical session.	Begoña Monterroso (CIB)	CIB*
	12:30-13:30	Fluorescence – Practical session.	Silvia Zorrilla (CIB)	CIB*
24/11	12:00-13:00	**MISB FRONTIERS:** Constructing minimal cells that can evolve	**Christophe DANELON** (TU-Delft, NL & Toulouse Biotech Inst, FR)	ONLINE
27/11	12:00-13:00	**MISB FRONTIERS:** Automated Glycan Assembly Enables the Glycosciences	**Peter H. SEEBERGER** Max-Planck Institute for Colloids and Interfaces, Potsdam, Germany	CIB
28/11				
29/11	10:00-12:00	**EXAM F1 (methods)**		
	16:00-18:00	**EXTENSION I:** (in the CIB MS Lecture Hall).	Javier García Martínez	CIB
FUNDAMENTALS 2 – Synthetic and systems biotechnology Basic principles and research topics				
30/11	10:00-11:00	Therapeutic bacteria: from probiotics to synthetic biology	Luis Ángel Fernandez (CNB)	CNB
	11:15-12:15		Esteban Veiga (CNB)	CNB
	12:30-13:30	Bacteria and immune system interface Amyloids as constructive parts in SynBio	Rafael Giraldo (CNB)	CNB
01/12				

DECEMBER 2023				
Day	**Hour**	**Lectures / Activities**	**Teacher**	**Room**
FUNDAMENTALS 2 – Synthetic and systems biotechnology Basic principles and research topics				
01/12	10:00-13:00			
04/12	10:00-13:00	**MISB FRONTIERS:** XXX (RD) **/** Essential physiological processes (division) in a genomically minimal cell (JP)	**Rumiana DIMOVA** (MPI-Colloids; Postdam) **James PELLETIER** (CNB)	ONLINE
05/12	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	HOLIDAY			
07/12				
08/12	HOLIDAY			
11/12				
12/12	10:00-11:00 11:15-12:15 12:30-13:30 15:00-16:00	High-throughput pathway assembly and optimization The SEVA project as a standardization approach Large-scale and high-throughput genome editing Introduction to plant synthetic biology and its biotechnological applications	Blas Blázquez (CNB) Esteban Martínez (CNB) Tomás Aparicio (CNB) Eduardo González (CNB)	CNB CNB CNB CNB
13/12	10:00-11:00 11:15-12:15 12:30-13:30	Biofactories based on synthetic bacterial compartmentalization Synthetic communities-based biofactories Assembling structured microbial ecosystems	Daniel López (CNB) Juan Nogales (CNB) Esteban Martínez (CNB)	CNB CNB CNB
14/12	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
15/12				
18/12		**JOURNAL CLUB**		
19/12	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
20/12	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
21/12				
22/12				
HOLIDAYS: 23/12/2023 – 07/01/2024				

JANUARY 2024				
Day	**Hour**	**Lectures / Activities**	**Teacher**	**Room**
FUNDAMENTALS 2 – Synthetic and systems biotechnology Basic principles and research topics				
08/01				
09/01	10:00-11:00 11:15-12:15 12:30-13:30	Enzyme biocatalysis for green chemistry: biotransformations mediated by microbial hydrolases Genome mining and rational design of new biocatalysts for lignocellulose biorefineries Evolution in the service of enzyme design	Alicia Prieto (CIB) Javier Ruiz-Dueñas (CIB) Susana Camarero (CIB)	CIB (-1) CIB (-1) CIB (-1)
10/01	10:00-11:00 11:15-12:15 12:30-13:30	Bacterial metabolic engineering for valorization of aromatic waste Carbon dioxide and hydrogen as feedstock for bacteria Metabolic engineering of yeast in waste revalorization	Eduardo Díaz (CIB) Gonzalo Durante (CIB) Carlos del Cerro (CIB)	CIB (-1) CIB (-1) CIB (-1)
11/01	10:00-11:00 11:15-12:15 12:30-13:30			
12/01				
15/01				
16/01	10:00-11:00 11:15-12:15 12:30-13:30	Biotechnology with metals: new challenges Nanotechnological tools: Dendrimeric and magnetic nanoparticles	Manuel Carmona Jesús Sanz	CIB (-1) CIB (-1)
17/01	10:00-11:00 11:15-12:15 12:30-13:30	Domesticating bacteria for tailored bioplastic production Engineering microbial cell factories by adaptive laboratory evolution Microbial cell to cell communication in biotechnology	Auxi Prieto Isabel Pardo Jorge Barriuso	CIB (-1) CIB (-1) CIB (-1)
18/01				
19/01				
22/01	10:00-12:00 16:00-17:30	**EXAM F2 (basic principles)** **EXT.I: Responsible research: Ethics in Synthetic Biology (Optional)**	Lluís Montoliu	CIB + ONLINE
FUNDAMENTALS 2 – Synthetic and systems biotechnology Methods and tools				
23/01	10:00-11:00 11:15-12:15 12:30-13:30	Biomolecular networks in synthetic biology (I) From gene regulatory networks to metabolic pathways. An introduction to biocircuits (II) An introduction to dynamic modeling in systems and synthetic biology, (III) Making a genetic toggle switch	Irene Otero-Muras (I2SysBio)	ONLINE
24/01	10:00-11:00 11:15-12:15 12:30-13:30	Practicum: Modeling Transcription and Translation (I) Practicum: Modeling Transcription and Translation (II) Queueing: proteases and degradation as a tool in synthetic biology	Javier Buceta (I2SysBio) Javier Buceta (I2SysBio) Arancha Urchueguia (I2SysBio)	ONLINE
25/01				
26/01	10:00-12:00	**JOURNAL CLUB**		
29/01				
30/01	10:00-11:00 11:15-12:15	Biocircuits & functional motifs (I): Introduction, parts, systems and devices (II): Automated design of biocircuits	Irene Otero-Muras (I2SysBio)	ONLINE

	12:30-13:30	(III): Optimization and control of biocircuits		
31/01	 10:00-11:00 11:15-12:15 12:30-13:30	Biocircuits & functional motifs (IV): Feed-forward motifs (V): The role of noise (VI):	Javier Buceta (I2SysBio)	ONLINE

FEBRUARY 2024				
Day	**Hour**	**Lectures / Activities**	**Teacher**	**Room**
FUNDAMENTALS 2 – Synthetic and systems biotechnology Methods and tools				
01/02				
02/02				
05/02				
06/02	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
07/02	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
08/02				
09/02				
12/02				
13/02	10:00-11:00 11:15-12:15 12:30-13:30	Sequence-based assignment of protein functional sites Analysis of biological networks: a complex-network approach	Florencio Pazos (CNB) Florencio Pazos	CNB CNB
14/02	10:00-11:00 11:15-12:15 12:30-13:30	Bottom-up assembly of microbial ecosystem from metagenome data Genome-Scale Metabolic Modeling	Javier Tamames (CNB) Juan Nogales	CNB CNB
15/02	10:00-11:00 11:15-12:15 12:30-13:30	Bacterial computing (I) Bacterial computing (II) Visit CBGP-UPM	Ángel Goñi (CBGP-UPM)	CBGP
16/02				
19/02	10:00-12:00	**JOURNAL CLUB**		
20/02				
21/02				
22/02	10:00-12:00	**EXAM F2 (methods)**		
23/02				
26/02				
27/02				
28/02				

29/02		**GRADE REPORTS – SEMESTER 1**		