



Master in Integrative Synthetic Biology

Engineering Biomolecular and Cellular Systems
Academic Year 2025-2026

COURSE 1 (MISB5) VERSION 17 OCTOBER 2025

SEMESTER 1 (10/2025 – 02/2026)

M1. FUNDAMENTALS (25 ECTS)

- Normally 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 – Engineering biomolecular and synthetic cell systems

F2: FUNDAMENTALS 2. Synthetic systems biotechnology – Engineering cellular systems.

EXAM F1 (05/11/2025 & 27/11/2025)

EXAM F2 (20/01/2026 & 19/02/2026)

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

27/02/2026: GRADE REPORTS SEMESTER 1

SEMESTER 2 (03/2026 – 06/2026)

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

M3. EXTENSION I

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

M4. INTEGRATED LABS I

(03-05/2026: 4-5 lab rotations; 06-07/2026: pending and extra lab rotations)

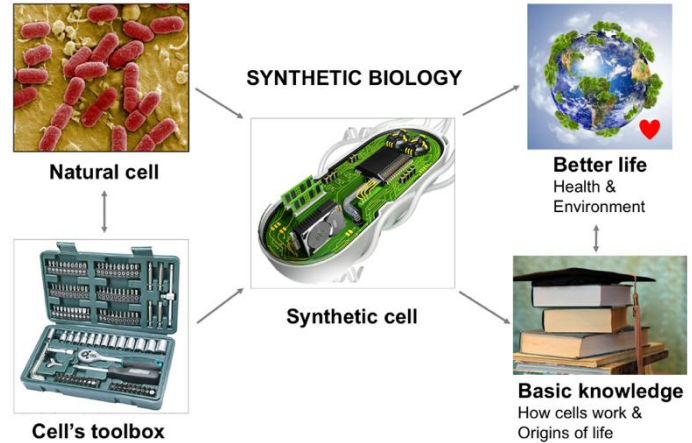
30/06/2026: GRADE REPORTS SEMESTER-

Synthetic biology: engineering biomolecular and cellular systems

SynBio offers a groundbreaking approach to **designing and assembling minimal biological or bio-inspired systems with tailored functionality.**

Mastering the intrinsic capabilities of biological systems:

- will enhance our **understanding of the fundamental principles of life** and how it emerges from non-living components.
- will also provide powerful tools for developing **innovative solutions** to pressing **environmental and health challenges.**



Mastering complexity / Understanding by building

Engineering Biology as a transformative technology

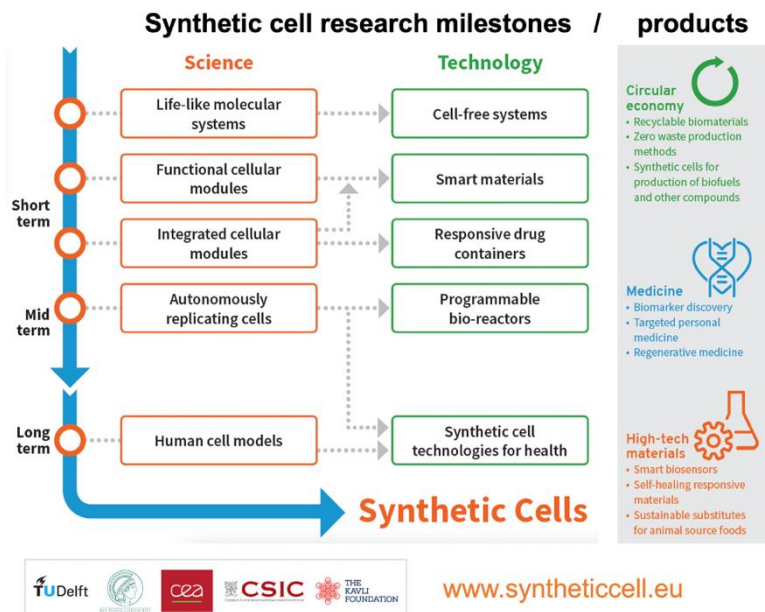
The most advanced countries have identified **engineering biology** as **one of the five critical and transformative technologies** for the coming decades (along with **AI** and **quantum computing**) and have planned and launched very ambitious programs accordingly.

- NL: **BaSyC, EVOLF**
- Germany: **MaxSynBio, BioSystemM, SynthImmune**
- UK: **BrisSynBio, FABRICELL**
- UK & Japan: **SYNTHESIS**
- US: **Build-A-Cell**
- Asia: **SYNCELL-ASIA**



European Synthetic Cell Initiative

Nature is our next technology



SEMESTER 1 (10/2025 – 02/2026)

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F0: FUNDAMENTALS 0. INTRODUCTORY SESSIONS

F1: FUNDAMENTALS 1. Synthetic molecular cell biology - Engineering biomolecular and synthetic cell systems

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EXAM F1 (05/11/2025 & 27/11/2025)

EXAM F2 (20/01/2026 & 19/02/2026)

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

27/02/2026: GRADE REPORTS SEMESTER 1

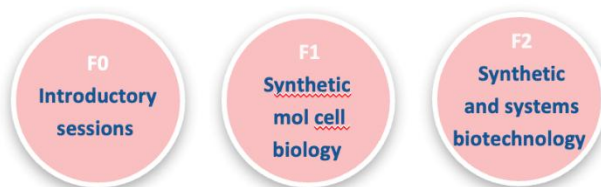


Master on Integrative Synthetic Biology

1 ST Semester	2 ND Semester	3 RD Semester	4 TH Semester
M1. FUNDAMENTALS (25 ECTS)			

M1A – Basic principles and research topics (15 ECTS)

M1B – Advanced methods (10 ECTS)



- **Bottom-up synthetic cell engineering-** reconstituting life-like molecular systems and functional modules and integrating them within artificial and natural cells.
- **Top-down synthetic biology-** from protein engineering, to reprogramming cell circuitry and / or metabolism to achieve novel functions, from cell therapeutics to cell factories.
- **Computational synthetic biology-** applying robotics, AI and Machine Learning tools.



Engineering biomolecular and cellular systems



OCTOBER 2025

All classes and seminars scheduled for October 2025 will be held in the seminar room on the -1 floor of CIB Margarita Salas, except for specific lectures, whose locations are listed in the program.

W#40

01/10

- 11:00-13:00 MISB5 – welcoming (MISB academic board and coordinators) / [CIB LECTURE HALL](#)

FUNDAMENTALS 0 – Introductory lectures

02/10

- 10:00-11:30 Synthetic biology: a diversity of approaches to master (Germán Rivas, CIB) / [CIB LECTURE HALL](#)

03/10

- 11:00-12:30 **OPENING LECTURE.** Design meets evolution: Theory and practice (V́ctor de Lorenzo, CNB) / [CIB LECTURE HALL & STREAMING.](#)

W#41

06/10

- 09:30-10:30 Synthetic Biology: a history of a yearny (Juli Peretó, I₂SysBio) / [ONLINE](#)
- 10:45-12:15 Chemical origins of life (Juli Peretó) / [ONLINE](#)

07/10

- 10:00-11:00 Introduction to FUNDAMENTALS (Germán Rivas, CIB)
- 11:30-12:30 Journal Club tutorial and instructions (G. Rivas, CIB)

08/10

CHEMISTRY FOR SYNTHETIC BIOLOGY - 1 (Ruth Pérez, CIB)

- 10:00-11:00 The chemistry of functional groups in molecules of biological interest
- 11:15-12:15 Basis of the Chemical Biology
- 12:30-13:30 Systems Chemical Biology

09/10

REVISITING BASIC CALCULUS TOOLS

- 10:30-13:00 Introduction to ODEs (Javier Buceta, I₂SysBio) / [ONLINE](#)

10/10

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FUNDAMENTALS 1 – Synthetic molecular cell biology (I)

W#42

13/10

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14/10

CHEMISTRY FOR SYNTHETIC BIOLOGY - 2 (Sonsoles Martín-Santamaría, CIB)

- 9:30-11:00 Conformation and tautomerism. Role in molecular recognition and biological function. Chirality. Stereoisomerism. Shape. Case studies.

MOLECULES OF LIFE AND THEIR INTERACTIONS

- 11:15-12:15 Macromolecules and small molecules (Sonsoles Martín-Santamaría, CIB)
- 12:30-13:30 Molecular recognition. Noncovalent interactions (Sonsoles Martín-Santamaría, CIB)

15/10

- 10:00-11:15 Molecular interactions: fundamentals of chemical equilibrium and kinetics (G. Rivas, CIB)
- 11:30-13:00 Molecular interactions: introduction to binding analysis (G. Rivas, CIB)

16/10

- 10:00-11:15 Nucleic acids (Carlos González et al., IQF)
- 11:30-13:00 Carbohydrates (Javier Cañada, CIB)

17/10

W#43

20/10

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21/10

- 10:00-11:15 Protein folding and assembly (Douglas Laurents, IQF)
- 11:30-13:00 Protein modifications (Dolores Pérez-Sala, CIB)

22/10

- 10:00-11:30 Lipids & Membranes (Iván López-Montero, UCM)
- 12:00-13:00 Engineering genomically minimal cells for integrative physiological studies (James Pelletier, CNB)

23/10

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24/10

- 12:00-13:00 **FRONTIERS SEMINAR** – In situ lipid synthesis: Construction of functional artificial cells (**Roberto Brea**, CICA – Univ. Coruña) / [CIB LECTURE HALL & STREAMING](#).

W#44

27/10

MACROMOLECULAR INTERACTIONS IN THE LIVING CELL: implications for synthetic cell research

- 10:00-11:00 Macromolecular crowding (Germán Rivas, CIB)
- 11:15-12:15 Macromolecular phase separation & biomolecular condensation (Silvia Zorrilla, CIB)
- 12:30-13:30 Surfaces as frameworks of macromolecular organization (Germán Rivas, CIB)

28/10

ESSENTIAL CELLULAR PROCESSES

- 10:00-11:00 Information processing – replication (Rodrigo Bermejo, CIB)
- 11:15-12:15 Information processing – transcription (Carlos Fdez. Tornero, CIB)
- 12:30-13:30 Information processing – gene transfer (Ernesto Arias, CIB)

29/10

- 10:00-11:15 Organization – signaling and cell adhesion (Daniel Lietha, CIB)
- 11:30-13:00 Organization – reverse engineering cytoskeleton (Thomas Surrey, CRG) / [ONLINE](#)

30/10

- 10:00-11:15 Organization - reverse engineering mitochondrial function (Iván López-Montero, UCM)
- 11:30-13:00 Organization – reverse engineering cell division (Germán Rivas, CIB)

31/10

NOVEMBER 2025

All classes and seminars scheduled for November 2025 will be held in the seminar room on the -1 floor of CIB Margarita Salas or in the seminar room of IQF Blas Cabrera, depending on the specific day (marked as CIB or IQF).

FUNDAMENTALS 1 – Synthetic molecular cell biology (II)

W#45

03/11

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04/11

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05/11

- **EXAM F1(I)**

06/11

PROTEIN PRODUCTION SESSION / CIB

- 10:00-10:45 Fundamentals of protein production tools (Cristina Vega, CIB)
- 11:00-11:45 Membrane protein production (Daniel Lietha, CIB)
- 12:00-12:45 Antibody production in cell-free systems (Francisco J. Fernández, Abvance)
- 13:00-13:45 In vitro reconstitution of cell-mimicking systems (Cristina Fernández, IBF) / ONLINE

07/11

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W#46

10/11

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11/11

INTEGRATED STRUCTURAL BIOLOGY: X-Ray crystallography tools / IQF

- 10:00-10:45 Fundamentals of X-ray Crystallography: from molecules to crystals and beyond (Juan A. Hermoso, IQF)
- 11:00-11:30 Membrane Maintenance at Contact Sites (Armando Albert, IQF)
- 11:40-12:10 Glyco-Synthetic Biology (Julia Sanz, IQF)
- 12:20-12:50 Conformational Versatility in Protein Complexes (Cristina Vega, CIB) / ONLINE

12/11

INTEGRATED STRUCTURAL BIOLOGY: NMR tools / IQF

- 10:00-10:45 NMR – fundamentals (Francisco Blanco, IBV-CSIC) / ONLINE
- 11:00-11:30 NMR – Nucleic acids (Carlos González, IQF)
- 11:30-12:00 NMR – Proteins (José M. Pérez Cañadillas, IQF)
- 12:30-13:00 NMR – Protein supramolecular assemblies (Javier Oroz, IQF)
- 13:00-13:30 NMR – Advanced NMR tools (Miguel Mompeán, IQF)
- 16:00-17:30 NMR – Practical session (Javier Cañada, CIB) / CIB

13/11

INTEGRATED STRUCTURAL BIOLOGY: Electron microscopy tools / CIB

- 10:00-11:00 Fundamentals: EM for the structural analysis of macromolecules (Carlos Fdez-Tornero, CIB)
- 11:15-12:15 EM – reconstructing cellular machines (1) (Ernesto Arias, CIB)
- 12:30-13:30 EM – reconstructing cellular machines (2) (Ernesto Arias, CIB)
- 15:00-17:00 EM – practical workshop (Rafael Nuñez & Begoña Pou, CIB)

14/11

- 10:00-12:00 Practical session: Crystallization, data collection, and structure solution (Lourdes Infantes, Beatriz González, IQF)

W#47

17/11

- JOURNAL CLUB F1?

18/11

MOLECULAR INTERACTIONS: Biophysical tools / CIB

- 10:00-11:00 AUC, light scattering (Juan R. Luque & Carlos Alfonso, CIB)
- 11:15-12:15 Calorimetry (ITC, DSC), circular dichroism (Begoña Monterroso, IQF)
- 15:00-16:30 Molecular interactions – practical workshop (Juan R. Luque & Carlos Alfonso, CIB)

19/11

MOLECULAR INTERACTIONS: Computational tools / CIB

- 10:00-11:00 Fundamentals (Sonsoles Martín-Santamaría, CIB)
- 11:15-12:15 Applications (Sonsoles Martín-Santamaría, CIB)
- 12:30-13:30 Practical cases (Sonsoles Martín-Santamaría, CIB)

CHEMICAL BIOLOGY

- 15:30-17:30 Chemical biology tools – chemical systems and probes (Ruth Pérez, CIB)

20/11

FLUORESCENCE & IMAGING / CIB

- 10:00-12:00 Fluorescence spectroscopy/microspectroscopy (Silvia Zorrilla, CIB)
- 16:00-17:00 Fluorescence – Practical sesión (Silvia Zorrilla, CIB)

21/11

- 12:00-13:00 **FRONTIERS SEMINAR** – Crowding in reconstituted cellular environments in synthetic cells (**Arnold Boersma**, Univ. Utrecht)

W#48

24/11

- 12:00-13:00 **FRONTIERS SEMINAR** – Design and chemical construction of quasi-living synthetic cells: bridging the molecular to microscopic scales – from fundamentals to biomedical applications. (**Cesar Rodriguez-Emmenegger**, Inst. Bioengineering Catalonia)

25/11

MICROFLUIDICS IN SYNTHETIC BIOLOGY / CIB

- 10:00-11:00 Droplet microfluidics (Begoña Monterroso, IQF)
- 11:30-12:30 Microfluidics – Practical session (Begoña Monterroso, IQF)
- 15:00-17:00 Single-molecule and super-resolution imaging (Marcelo Nollmann, CBS Montpellier) / ONLINE

26/11

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27/11

- EXAM F1 (II)

28/11

DECEMBER 2025

All classes and seminars scheduled for December 2025 will be held in the seminar room at the Centro Nacional de Biotecnología (CNB), except the ones on 10/12 and 11/12, which will be at the Instituto de Catálisis (ICP)

FUNDAMENTALS 2 – Synthetic systems biotechnology (I)

W#49

01/12

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02/12

- 10:00-11:00 Therapeutic bacteria: from probiotics to synthetic biology (Luis Ángel Fernández, CNB)
- 11:15-12:15 Synthetic Biology in Oncology: Designing the Next Generation of Cancer Therapies (Esteban Veiga, CNB)
- 12:30-13:30 Amyloids as constructive parts in SynBio (Rafael Giraldo, CNB)

03/12

- 10:00-11:00 Optogenetics (Rafael Giraldo, CNB)
- 11:15-12:15 In vivo directed evolution of proteins (Beatriz Álvarez, CNB)
- 12:30-13:30 Introduction to stochastic processes (Saúl Ares, CNB)

04/12

- 10:00-11:00 Genome-Scale Metabolic Modeling (Juan Nogales, CNB)
- 11:15-12:15 The SEVA project as a standardization approach (Esteban Martínez, CNB)
- 12:30-13:30 Large-scale and high-throughput genome editing (Tomás Aparicio, CNB)

05/12

W#50

08/12

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09/12

- 10:00-11:00 Biofactories based on synthetic bacterial compartmentalization (Daniel López, CNB)
- 12:15-12:15 Assembling structured microbial ecosystems (Esteban Martínez, CNB)

10/12

- 10:00-11:00 Carbohydrate-active enzymes for applications in health and sustainable chemistry (Marina Minguet, ICP) / ICP
- 11:15-12:15 Why integrate mimetic surfaces and some biophysical tools to study them (Marisela Vélez, ICP)
- 12:30-13:30 High-throughput pathway assembly and optimization (Blas Blázquez, CNB)

11/12

- 10:00-11:00 Engineering cell factories for production of chemicals and fuels (Eva García, ICP) / ICP
- 11:15-12:15 The revolution of directed evolution (Miguel Alcalde, ICP)
- 12:30-13:30 Visit EvoEnzyme (EvoEnz)

12/12

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W#51

15/12

- 10:00-11:00 Standards in synthetic biology (Manel Porcar, I2SysBio) / ONLINE
- 11:15-12:15 Metabolic engineering of food-producing yeasts (Agustín Aranda, I2SysBio) / ONLINE

16/12

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17/12

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18/12

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19/12

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W#51

- **HOLIDAY**

JANUARY 2026

FUNDAMENTALS 2 – Synthetic systems biotechnology (I)

W#2

05/01

- HOLIDAY

06/01

- HOLIDAY

07/01

- HOLIDAY

08/01

- 10:00-11:00 Enzyme biocatalysis for green chemistry: biotransformations mediated by microbial hydrolases (Alicia Prieto, CIB)
- 11:15-12:15 Genome mining and rational design of new biocatalysts for lignocellulose biorefineries (Javier Ruiz-Dueñas, CIB)

09/01

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W#3

12/01

- 10:00-11:00 Exploring the past with ancestral protein resurrection to understand and engineer enzymes (Iván Ayuso, CIB)
- 11:15-12:15 Evolution in the service of enzyme design (Susana Camarero, CIB)
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13/01

- 10:00-11:00 Bacterial metabolic engineering for valorization of aromatic waste (Eduardo Díaz, CIB)
- 11:15-12:15 Carbon dioxide and hydrogen as feedstock for bacteria (Gonzalo Durante, CIB)

14/01

- 10:00-11:00 Biotechnology with metals: new challenges (Manuel Carmona, CIB)
- 11:15-12:15 Nanotechnological tools: Dendrimeric and magnetic nanoparticles (Jesús Sanz, CIB)
- 12:30-13:30 Lignin valorization into building blocks for bioplastics production (Helena Gómez, CIB)

15/01

- 10:00-11:00 Domesticating bacteria for tailored bioplastic production (Auxi Prieto, CIB)
- 12:30-13:30 Microbial cell-to-cell communication in biotechnology (Jorge Barriuso, CIB)

16/01

- 12:00-13:00 **FRONTIERS SEMINAR – TBA (Catherine Royer, Rensselaer Polytechnic Inst, NY)**

FUNDAMENTALS 2 – Synthetic systems biotechnology (II)

W#4

19/01

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20/01

- EXAM F2 (I)

21/01

BIOMOLECULAR NETWORKS IN SYNTHETIC BIOLOGY (Irene Otero-Muras, I2SysBio) / ONLINE

- 10:00-11:00 From gene regulatory networks to metabolic pathways. An introduction to biocircuits
- 11:15-12:15 An introduction to dynamic modeling in systems and synthetic biology
- 12:30-13:30 Making a genetic toggle switch

22/01

BIOMOLECULAR NETWORKS IN SYNTHETIC BIOLOGY (Javier Buceta, I2SysBio) / [ONLINE](#)

- 10:00-11:00 Practicum: Modeling Transcription and Translation (I)
- 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

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W#5

26/01

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27/01

BIOCIRCUITS & FUNCTIONAL MOTIFS (Irene Otero-Muras, I2SysBio) / [ONLINE](#)

- 10:00-11:00 (I) Introduction, parts, systems, and devices
- 11:15-12:15 (II) Automated design of biocircuits
- 12:30-13:30 (III) Optimization and control of biocircuits

28/01

BIOCIRCUITS & FUNCTIONAL MOTIFS (Javier Buceta, I2SysBio) / [ONLINE](#)

- 10:00-11:00 (IV) Feed-forward motifs
- 11:15-12:15 (V) The role of noise
- 12:30-13:30 (VI) Multicellular Environments: QS and Tissues

29/01

- 10:00-12:00 Introduction to AI and applications in Synthetic Biology (Raúl Fernández, IBBTEC) / [ONLINE](#)

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30/01

- **FRONTIERS SEMINAR?**

FEBRUARY 2026

W#6

02/02

- JOURNAL CLUB F2

03/02

DE NOVO SYNTHETIC BIOLOGY (Alfonso Jaramillo, I2SysBio) / ONLINE

- 10:00-11:00 Examples of de novo RNA sequences with targeted function (ribo regulators, de novo ribozymes, etc)
- 11:15-12:15 Computational and experimental design of de novo RNA sequences with targeted function
- 12:30-13:30 De novo virus design

04/02

AUTOMATED DESIGN FOR METABOLIC ENGINEERING AND SYNTHETIC BIOLOGY (Pablo Carbonell, I2SysBio) / ONLINE

- 10:00-11:00 The Design-Build-Test-Learn cycle of biomanufacturing
- 11:15-12:15 Computational Protein Design
- 12:30-13:30 Metabolic Pathway Design

05/02

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06/02

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W#7

09/02

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10/02

- 10:00-11:00 Sequence-based assignment of protein functional sites (Florencio Pazos, CNB)
- 11:15-12:15 Analysis of biological networks: a complex-network approach (Florencio Pazos, CNB)

11/02

- 10:00-11:00 Bottom-up assembly of microbial ecosystem from metagenome data (Javier Tamames, CNB)
- 11:15-12:15 Synthetic communities-based biofactories (Juan Nogales, CNB)
- 12:30-13:30 New tools to study plasmid-mediated antimicrobial resistance (Álvaro San Millán, CNB)

12/02

- 10:00-11:00 Bacterial computing (I) (Ángel Goñi, CNB)
- 11:15-12:15 Bacterial computing (II) (Ángel Goñi, CNB)

13/02

- FRONTIERS SEMINAR?

W#8

16/02

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17/02

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18/02

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19/02

- EXAM F2 (II)

20/02

- **END SEMESTER 1**

W#9

23/02

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24/02

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25/02

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26/02

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27/02

- **CLOSING EVALUATION SEMESTER 1**