UAB
Universitat Autònoma de Barcelona

Synthetic Biology

Code: 107533
ECTS Credits: 6

2025/2026

Degree	Type	Year
Biotechnology	OP	4

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

There are no prerequisites for this course, but it is recommended to have taken courses in molecular biology as well as chemistry, and protein engineering.

Objectives and Contextualisation

This course aims to introduce students to Synthetic Biology as an interdisciplinary field combining molecular biology, genetic engineering, chemistry and computational biology. Through lectures, practical sessions, and a research project, students will acquire the conceptual and experimental tools required to:

1. Understand the foundations of synthetic biology and how it differs from traditional genetic engineering.
2. Design and analyze genetic circuits, biological computers, and molecular regulatory systems.
3. Learn strategies for the de novo design of genomes, proteins, and metabolic pathways using computational models and artificial intelligence.
4. Apply this knowledge to the creation of organisms with novel functions, such as live biotherapeutics, biosensors, and engineered microbes.
5. Reflect on the ethical, legal, and societal implications of synthetic biology, including biohacking, human enhancement, and genetic code modification.

Learning Outcomes

1. CM25 (Competence) Work collaboratively in teams to solve problems in the field of systems biology.
2. KM27 (Knowledge) Determine the environmental impact of the use of synthetic biology in biotechnological production.
3. SM23 (Skill) Use the fundamentals of mathematics, physics and chemistry necessary for the study of regulatory mechanisms at the molecular level in living beings.
4. SM24 (Skill) Quantitatively model a biological process or system.

Content

I. Introduction to Synthetic Biology

Module 1: Fundamentals of Synthetic Biology

1. Definition and scope
   • History and evolution of synthetic biology.
   • Differences from traditional genetic engineering.
   • Impact on biotechnology and biomedicine.
   • Goals and challenges of synthetic biology.

II. Biological Design

Module 2: Biological Circuits and Molecular Computers

1. Fundamentals of genetic circuits
   • Gene regulation: promoters, repressors, and other elements.
   • Strategies for modularity and circuit reconfiguration.
   • Genetic switches, oscillators, and bistable behavior.
   • Transcriptional and post-transcriptional regulation.
   • Use of evolutionary algorithms to optimize genetic circuit designs.

2. Building biological computers
   • Implementation of logic gates at the cellular level.
   • Biological sensors and detection systems.
   • Biocomputation and cellular memory.
   • Simulations and experimental prototypes.

Module 3: Design of Synthetic Organisms

1. Synthesis of artificial genomes
   • Construction of minimal genomes: the case of *Mycoplasma laboratorium*.
   • Large-scale DNA assembly and synthesis protocols.
   • Engineering complete genomes using artificial intelligence.
   • Optimization of cellular chassis for industrial applications.

2. Generation of new enzymes and metabolic pathways
   • AI models for macromolecule design.
   • Artificial biological catalysis.
   • Creation of new chemical and pharmaceutical products *in silico*.

3. Biotechnological applications of *de novo* design
   • Design of synthetic photosynthetic organisms.
   • Production of biopharmaceuticals and biocompatible materials.
   • Environmental biosensors.
   • Synthetic organisms in bioenergy.

III. Applications of Synthetic Biology

Module 4: Living Pills and Therapeutic Microorganisms

1. Engineering therapeutic microbiomes
   • Microbes as drug factories within the body.
   • Engineered bacteria for disease detection and treatment.
   • Modulation of immune responses through modified microorganisms.
   • Strategies to avoid adverse immune reactions.
   • Legislation and biosafety regulations.
   • Risk-benefit assessments in humans.

Module 5: Modification and Expansion of the Genetic Code

1. Incorporating new amino acids into the genetic code
   • Molecular foundations of genetic code engineering.
   • Genetic code expansion. Orthogonality. Engineered tRNA transferases and synthetases.
   • Production of fluorescent proteins, synthetic catalysts, and novel materials.

2. Evolutionary consequences and safety of expanded genetic codes
   • Long-term effects in cells and organisms.
   • Biocontainment and strategies to prevent horizontal gene transfer.

Module 6: Biohacking, Human Enhancement, and Ethics

1. Biohacking and experimentation in synthetic biology
   • Notable biohacking cases and DIYbio communities.
   • Legal and regulatory limitations.

2. Human enhancement and brain-machine interfaces
   • Genetics of human enhancement: possibilities and technical limitations.
   • Enhanced abilities: physical (myostatin and FOXP2), cognitive (regulation of SCN9A and NR2B), and sensory (modification of opsin 1, PDE6H or TMC1).
   • Engineering symbiotic bacteria to improve detoxification or nutrient absorption.
   • Regulation of aging, organic rejuvenation, and consciousness transfer.
   • Brain-machine interfaces and digital telepathy: Applications of Neuralink, BrainGate, Kernel, or NextMind.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	35	1.4	KM27, SM23, SM24, KM27
Problems/specific subjects	10	0.4	CM25, KM27, SM23, CM25
Type: Supervised			
Research project	12	0.48	CM25, KM27, SM23, SM24, CM25
Tutorials in classroom	4	0.16	SM23, SM24, SM23
Type: Autonomous			

Individual study	67	2.68	SM23, SM23
Individual study of specific subjects	15	0.6	SM23, SM23

Lectures
Lectures are a fundamental component of the course and are designed to provide a solid and well-structured foundation of the most relevant content. In addition to explaining key concepts, the instructor will encourage active participation through open questions, brief debates, and contextualized examples that help connect theoretical content to real-world cases and practical applications. These sessions also offer the opportunity to interact directly with the instructor and peers, clarify doubts in real time, and consolidate learning in a more dynamic and participatory way. All materials will be available at the Moodle virtual area.

Problem-solving sessions
These sessions aim to reinforce theoretical knowledge through the analysis and resolution of exercises based on the course content. Two complementary formats will be used:

1. Structured problems
At the end of each thematic unit, students will work on closed or semi-open problems designed to practice and internalize the fundamental concepts-such as the design of genetic circuits. These exercises help identify specific challenges and strengthen understanding of basic tools.

2. Contextualized and open-ended problems
As the course progresses, more complex and realistic scenarios will be introduced. These will require integrating knowledge, making justified decisions, and exploring alternative solutions. These problems will be solved in small groups to promote active participation,collaborative reasoning, and critical discussion. Evaluation will consider both the resolution process and the ability to justify and communicate decisions.

Groups will take turns drafting a short written report on one of the problems, which will serve as a basis for class-wide discussion. This approach seeks to balance technical mastery with active and collaborative learning.

Group tutorials
Tutorial sessions are designed as spaces for academic guidance and support. The main objective is to help students plan and approach the autonomous learning components of the course effectively. The instructor will provide strategies to organize study time, identify key concepts, and make optimal use of the available learning materials. These sessions will also offer an opportunity to address general questions, share common difficulties, and reflect on the learning process itself.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Contextualized problem-solving	10%	0.5	0.02	CM25, KM27, SM23, SM24
Laboratory practical sessions	25%	0.5	0.02	CM25, SM23, SM24
Research project	40%	3	0.12	CM25, SM23, SM24
Written exam	25%	3	0.12	CM25, KM27, SM23, SM24

Continuous assessment

The assessment of this course is based on four components combining individual and group work, practical application, and theoretical reasoning. The goal is to evaluate both conceptual understanding and the ability to integrate and apply knowledge in a critical and creative way.

1. Research project (40%)
   Each student will develop a research project on a topic related to synthetic biology, either proposed by the student or suggested by the instructor. The project must integrate the knowledge acquired during the course, with particular emphasis on Block II (biological design). The objective is not to produce a conventional literature review, but to apply the acquired knowledge to address a relevant scientific question or respond to a current technological need.

Projects will be presented and assessed through a peer review system involving the entire class. This dynamic encourages critical thinking and collective engagement. At the end of the course, all projects will be compiled into a collaborative digital journal.

1. Contextualized problem-solving (10%)
   Active participation in group problem-solving sessions will be assessed. Each group will take turns preparing and presenting a brief written report on one of the cases discussed in class. Evaluation will consider argumentation skills, clarity of presentation, and teamwork.

2. Laboratory practicals (25%)
   Assistance to the laboratory practials is required to pass the course. Lab sessions provide hands-on experience with experimental tools relevant to synthetic biology. Assessment will be based on an individual report analyzing the results obtained, the methodology used, and the interpretation of the observed phenomena. Critical analysis, clarity of writing, and scientific rigor will be valued.

3. Written exam (25%)
   The written exam will assess the student's understanding of the fundamental concepts of the course, as well as reasoning ability and content integration. It will include both conceptual and applied questions. Any material covered in lectures, problem sessions, or independent study may be included. A minimun of 4 points in the written exam is required to pass de course.

Submitted assignments are not eligible for resubmission or recovery.

Students may take a resit exam to attempt to improve their score on the written test. In this case, the grade obtained in the resit exam will replace the previous grade, even if it was higher.

The course will be considered passed when the total weighted score is equal to or greater than 5 out of 10, if all conditions are met for all evaluation parts.

To be eligible for evaluation, students must have been assessed in activities representing at least two-thirds (67%) of the course's total assessment weight. Students will receive a "Not Assessable" mark if their assessed activities account for less than 67% of the final grade.

This course does not offer a single final assessment option.

Bibliography

Lehninger: Principles of Biochemistry. D.L. Nelson & M.M. Cox (2021) 8th edition, W. H. Freeman.

Biobuilder: Synthetic Biology in the Lab. Natalie Kuldell, Rachel, Bernstein, Karen Ingram & Kathryn Hart (2015) 1st edition, O'Reilly Media

Synthetic Biology: From iGEM to the Artificial Cell. Manuel Porcar & Juli Peretó (2014) 1st edition, Springer.

Synthetic Biology (2 Volumes). Robert A. Meyers (2015) 1st edition, Blackwell Verlag GmbH.

An Introduction to Systems Biology: Design Principles of Biological Circuits, Uri Alon (2019) 2nd edition, Chapman and Hall/CRC.

Software

CellDesigner: A modeling tool of biochemical networks (http://www.celldesigner.org)

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.