UAB
Universitat Autònoma de Barcelona

Synthetic Biology, Systems Biology and Metabolic Engineering

Code: 44997
ECTS Credits: 6

2024/2025

Degree	Type	Year
4313772 Advanced Biotechnology	OB	0

Contact

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Teachers

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Teaching groups languages

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Prerequisites

A degree in Biotechnology, Biochemistry, Microbiology, Genetics, Bio/Chemical Engineering or similar are required.

Basic knowledge of Catalan language is required

Objectives and Contextualisation

The main objective of this module is to explore, acquire a high level of comprehension and be able to evaluate the different emerging methodologies in the fields of Synthetic Biology, Systems Biology and Metabolic Engineering. This includes the different '-omics' platforms for the integrated, global and quantitative analysis of cell physiology as a knowledge base for the Enzyme and Metabolic Engineering. That is for the rational design and improvement of cell lines, microorganisms or enzymes with the goal of its industrial or therapeutic application.

Competences

- Combine analytic and computational methodologies and tools for quantitative analysis, massive data processing and modelling ("omic" platforms and systems biology) of organisms or parts of these.
- Continue the learning process, to a large extent autonomously.

- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
- Synthesise, weigh up alternatives and engage in critical discussion.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.
- Use and manage bibliography and IT resources related to biotechnology responsibly.
- Use appropriate methodologies for the rational design and improvement (synthetic biology and metabolic engineering) of enzymes, organisms and cell lines for industrial or clinical use.
- Work in a multidisciplinary team.

Learning Outcomes

1. Continue the learning process, to a large extent autonomously.
2. Describe the principles and use the appropriate tools and methodologies to design and construct new industrial organisms or their parts.
3. Describe the principles and use the tools and methodologies of synthetic biology.
4. Design strategies to improve cell factories based on information obtained from "omic" analysis.
5. Identify the basic characteristics and use of various computational tools for massive data processing and cell/metabolic modelling.
6. Identify the restrictions/limitations (and selection criteria) of synthetic biology tools for application in the field of industrial biotechnology.
7. Investigate the applicability of "omic" platforms for obtaining physiological data for the experimental design of strategies to improve cell factories.
8. Investigate the applicability of massive, transcriptomic, proteomic, fluoxomic and metabolomic sequencing techniques in the study of industrial organisms.
9. Recognise techniques like random mutagenesis, evolutionary engineering and screening of cDNA/genomic libraries for optimising enzymes, microorganisms and industrial cell lines.
10. Set criteria for the combined use of directed and non-directed improvement techniques (metabolic engineering and synthetic biology).
11. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
12. Synthesise, weigh up alternatives and engage in critical discussion.
13. Use (at the level of user) computational tools for the analysis and modelling of data obtained through omic in silicoplatforms with the aim of obtaining useful biological information for designing, modelling and improving industrial microorganisms.
14. Use (at the level of user) various computational tools for massive processing of data obtained through omic platforms.
15. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.
16. Use and manage bibliography and IT resources related to biotechnology responsibly.
17. Work in a multidisciplinary team.

Content

Unless the requirements enforced by the health authorities demand a prioritization or reduction of contents, the course will include:

1.- Omic platforms: Application of Systems Biology '-omic' analytical tools - from genomics and transcriptomics to metabolomics and fluxomics- for the engineering of industrial microorganisms.

2.- Metabolic Engineering and systems Biology: Bottom-up analysis and modelling of metabolism/cell function. Metabolic control theory. *In-silico* design of directed genetic modifications. Top-down analysis from analytical 'omic' platforms, including data treatment and its multilevel analysis. Global metabolic analysis using *in-silico* genome-scale metabolic models. Study cases: Applications of metabolic engineering and systems biotechnology to the improvement of strains producing small molecules (amino acids, antibiotics, etc.) and/or obtain robust strains adapted to industrial conditions (high levels of toxic compounds, etc.).

3.- Applied synthetic biology: construction and design of new industrial microorganisms or their parts - for example, construction of new metabolic routes- to obtain cell factories and/or biocatalyzers for the efficient production of biological compounds, new generation biofuels (butanol, jet fuel, etc.), APIs, industrial enzymes or therapeutic proteins.

4.- High throughput technologies: Application of non-directed techniques (combined with metabolic engineering strategies) for the optimization of enzymes, organisms and industrial cell lines: directed evolution, mutagenesis, library screening, etc. Case studies: Production of enzymes tolerant to solvents, pH, high temperature, etc. Generation of robust industrial strains. Case studies: Tolerance to ethanol, phenolic compounds, high osmolarity, etc.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lecture classes	22	0.88	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 15, 16
Practical classes (computer)	16	0.64	5, 13, 14
Type: Supervised			
Preparation of team work, solving exercises or practical cases	7	0.28	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17
Type: Autonomous			
Personal study	39	1.56	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
Preparation of team work, solution of exercises or practical cases	58	2.32	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17

The proposed teaching methodology may experience some modifications depending on the restrictions to face-to-face activities enforced by health authorities.

The teaching methodology that will be used throughout the learning process is based essentially on the work of the student and the faculty professors will be responsible for helping them both with regard to the acquisition and interpretation of information related to the subject as in the direction of their work. In general, training activities will be distributed in the following types:

Lecture classes: They will be used to provide students with the basic conceptual elements and the minimum information necessary so that they can then develop autonomous learning. IT resources will be used (ppt or pdf presentations) that will be available to the student on the virtual platform.

Practical computer class: Part of the competencies of the subject will be acquired by means of the computer practical classes. In this case, the most convenient software will be used in order to better understand the behavior of biological systems, carry out various analyses, as well as be able to design and test in-silico various strain improvement methodologies as a step prior to its application in the laboratory. Practical exercices will be delivered trough virtual campus. If not delivered, the practical graded exercices mark will be penalyzed.

Group work: Small groups of students will also be assigned a group work based on a scientific publication that will be presented to classmates.

Individual tutor appointments: Individual tutor appointments can be done at the request of the students. The objective of these will be, for example, the solution of doubts and/or orientation on the sources of information available.

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
Class participation (activity D)	10	0	0	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15
Exercices delivered (activity A)	30	0	0	1, 5, 13, 14, 16
Team work oral presentation (activity B)	30	5	0.2	1, 11, 12, 16, 17
Theory or practical exams (activity C)	30	3	0.12	1, 2, 3, 4, 6, 7, 8, 10, 11, 12, 15

Assessment activities:

- Activity A: Delivery of practical graded exercises with computer: 30% on the final grade

- Activity B: Oral defense of team work: 30% on the final grade

- Activity C: Theory or practical exams: 30% on the final grade

- Activity D: Attendance and active participation to the classes: 10% on the final grade

Keep in mind that activity D is not recoverable. Therefore, any recovery activity will not allow achieving the maximum grade.

Programming evaluation activities: The dates of the written tests and the submission of exercises and team work will be published in the academic calendar or on the virtual campus and may be subject to possible schedule changes for reasons of adaptation to unforeseen events. Always be informed through the virtual platform about these changes as it is understood that this is the usual platform for exchange of information between faculty professors and students.

For each type A or C assessment activity, a place, date and time in which the student will be able to review the activity with the professor will be indicated. If the student does not show up for this revision, this activity will not be reviewed later.

Recovery: In case of not passing the subject by the previous procedure a synthesis test is foreseen to be able to pass the course. Keep in mind that the highest possible score in this test is 'Notable'. In order to access the recovery test it is necessary to have attended at least two thirds of the evaluable activities.

'No Evaluable': Any student who fails to present at least two-thirds of the assesment activities described previously will be rated as 'No Evaluable' meaning that the progress can not be assessed.

Awarding an honor grade (MH) is the decision of the faculty members responsible for the course.The UAB regulations indicate that the MH can only be granted to students who have obtained a final grade equal to or greater than 9.00 but the professorshipcan fix a higher minimum level if there are more candidates than the maximum number of honors available, or request for complementary activities. It can only be given up to 5% of MH of the total number of studentsenrolled.

Plagiarism: Without prejudice to other disciplinary measures deemed appropriate, and in accordance with current academic regulations, any irregularities committed by a student that may lead to a variation of the grade of evaluation activity will be scored with a zero. Therefore, copying, plagiarism, cheating, letting copy, etc. in any of the evaluation activities it will involve failing it with a zero. The evaluation activities qualified in this way and by this procedure will not be recoverable. If it is necessary to pass any of these evaluation activities to pass the subject, this subject will be failed directly, with no opportunity to recover it in the same course. In this case, the grade of the subject will be 3.5.

Evaluation of students enrolled in previous courses: As of the second enrollment, the evaluation of the subject will consist of a synthesis test. Alternatively, the final grade of the subject can be calculated as the average of activities A, B and C. In order to be eligible for this type of evaluation, the repeating student must request it to the professor via e-mail (pau.ferrer@uab.cat) at latest 8 days after the start of the classes of this course.

Bibliography

Alon, U. An Introduction to Systems Biology. Design principles of biological circuits. Second edition. Chapman & Hall/CRC. 2019. (https://bibcercador.uab.cat/permalink/34CSUC_UAB/avjcib/alma991009937489706709)
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Stephanopoulos G.N. Aristidou A.A. Nielsen J. Metabolic Engineering. Principles and Methodologies. Academic Press. San Diego. USA, 1998 (https://bibcercador.uab.cat/permalink/34CSUC_UAB/1c3utr0/cdi_askewsholts_vlebooks_9780080536286))
Szallasi, Z., V. Periwal, i J. Stelling. System Modeling in Cellular Biology: From Concepts to Nuts and Bolts. The MIT Press, 2006.

Software

- COPASI (http://copasi.org/)

- Optflux (http://www.optflux.org/)

- Microsoft Excel

- Matlab (https://es.mathworks.com/academia/tah-portal/universitat-autonoma-de-barcelona-40811157.html)

Language list

Name	Group	Language	Semester	Turn
(PAULm) Classroom practices (master)	1	Catalan/Spanish	second semester	afternoon
(TEm) Theory (master)	1	Catalan/Spanish	second semester	afternoon