Universitat Autònoma de Barcelona

2022/2023

Synthetic Biology and Metabolic Engineering

Code: 43330
ECTS Credits: 6

Degree	Type	Year	Semester
4314579 Biological and Environmental Engineering	OT	1	2

Contact

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Use of Languages

Principal working language: spanish (spa)

Other comments on languages

Most of the provided additional material is written in English. Catalan, spanish or english are used interchangeably

Teachers

Pau Ferrer Alegre

Prerequisites

Student must have medium level knowledge in Mathematics, Chemistry, Microbiology and basic level of Molecular biology.

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

- Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of biological and environmental engineering.
- Communicate and justify conclusions clearly and unambiguously to both specialist and non-specialist audiences.
- Continue the learning process, to a large extent autonomously.
- Integrate and use biotechnology and bioprocess engineering tools to solve problems in emerging biotechnological areas for the industrial production of bioproducts.
- Integrate and use chemical, environmental and/or biological engineering tools to design biological systems for the sustainable processing of waste and/or for industrial biotechnological processes.
- Seek out information in the scientific literature using the appropriate channels and integrate this information, showing a capacity for synthesis, analysis of alternatives and critical debate.

- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
- Use IT tools to acquire further knowledge in the field of biological and environmental engineering.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.
- Work in a multidisciplinary team.

Learning Outcomes

1. "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."
2. "Investigate the applicability of ""omic"" platforms for obtaining physiological data for the experimental design of strategies to improve cell factories."
3. Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of biological and environmental engineering.
4. Communicate and justify conclusions clearly and unambiguously to both specialist and non-specialist audiences.
5. Continue the learning process, to a large extent autonomously.
6. Identify the advantages and disadvantages of emerging technologies in the fields of synthetic biology and systems biology.
7. Identify the basic characteristics and use of various computational tools for massive data processing and cell/metabolic modelling.
8. Seek out information in the scientific literature using the appropriate channels and integrate this information, showing a capacity for synthesis, analysis of alternatives and critical debate.
9. Set criteria for the combined use of directed and non-directed improvement techniques (metabolic engineering and synthetic biology).
10. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
11. Use IT tools to acquire further knowledge in the field of biological and environmental engineering.
12. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.
13. 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.
14. Work in a multidisciplinary team

Content

1.- Omic platforms: Application of Systems Biology '-omic' analytical tools - from genomics, transcriptomics, metabolomics and fluxomics- to 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,...).
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, 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. Obtain robust industrial strains. Case studies: Tolerance to Ethanol, phenolic compounds, high osmolarity, etc..

Methodology

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 regards to the acquisition and interpretation of information related to the subject as well 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 slides) that will be available to the student on the virtual platform.

Practical computer classes: 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 prior step 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 clarification of doubts and/or orientation on the available sources of information.

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.

Activities

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

Assessment

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 activities, a place, date and time in which the student will be able to review the activity with the teacher 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 of this course by the previous procedure, a synthesis test is foreseen as a necessary assessment activity for passing 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 assessment activities.

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

Awarding an honor grade (MH) is the decision of thefaculty 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, 9.0 but the professorship can fix a higher minimum level if there are more candidates than the maximum number of honors available, or request for complementary activities. The number of MH that can be given is limited up to the 5% of the total number of students enrolled in this course.

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, allowing someone to copy, etc. in any of the assessment or evaluation activities, will involve failing it and will receive a zero mark. 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 faculty members via e-mail at the very late 8 days after the start of the classes of this course.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Class participation (activity D)	10	0	0	6, 4, 5, 14
Exercises delivered (activity A)	30	0	0	1, 3, 8, 13
Team work oral presentation (activity B)	30	5	0.2	1, 9, 7, 2, 10, 4, 14, 13
Theory or practical exams (activity C)	30	3	0.12	3, 9, 6, 12, 11

Bibliography

Alon, U. An Introduction to Systems Biology. Design principles of biological circuits. Second edition. Chapman & Hall/CRC. 2019.
(https://web-s-ebscohost-com.are.uab.cat/ehost/ebookviewer/ebook?sid=af22999a-df3d-4af7-8dd4-c4f7a02ee22

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Klipp, E., R. Herwig, A. Kowald, C. Wierling, i H. Lehrach. Systems Biology in Practice. Concepts implementation and application. Weinheim: Wiley-VCH, 2005. (https://onlinelibrary-wiley-com.are.uab.cat/doi/book/10.1002/3527603603)
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Nielsen, J.; Hohmann, S. Systems Biology. Wiley-Blackwell. 2017 (https://onlinelibrary-wiley-com.are.uab.cat/doi/book/10.1002/9783527696130)
Palsson, B.O. Systems Biology. Properties of reconstructed networks. Cambridge: Cambridge University Press, 2006.
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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)