Universitat Autònoma de Barcelona

2023/2024

Industrial Biochemistry

Code: 100909
ECTS Credits: 6

Degree	Type	Year	Semester
2500252 Biochemistry	OB	3	1

Contact

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Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Teachers

Jaime Farrés Vicén

Prerequisites

There are no compulsory prerequisites. However, part of the contents of some 1st year and 2nd year courses are needed to be able to follow the course correctly. In particular, those of the following courses: Biocatalysis, Molecular Biology, Microbiology and Cell Culture.

Objectives and Contextualisation

The course aims to integrate the knowledge of biochemistry and molecular biology with those of microbiology and biochemical engineering, with emphasis on their application to the biotechnological processes.

Competences

- Apply the legal and ethical principles that govern the development and application of molecular life sciences.
- Apply the principal techniques used in biological systems: methods of separation and characterisation of biomolecules, cell cultures, DNA and recombinant protein techniques, immunological techniques, microscopy techniques, etc.
- Be able to self-evaluate.
- Clearly perceive current advances and possible future developments by reviewing scientific and technical literature in the area of biochemistry and molecular biology.
- Collaborate with other work colleagues.

- Combine research and and the generation of knowledge with problem-solving in one's own field, showing sensibility to ethical and social questions.
- Demonstrate understanding and use of the mechanisms of biological catalysis based on the structure of biological catalysts and chemical reactions.
- Describe the structural, physiological and biochemical characteristics of the different types of cells and explain how their properties fit in with their biological function.
- Integrate knowledge of biochemistry and molecular biology with that of microbiology and biochemical engineering, especially in their application to biotechnological processes.
- Make an oral, written and visual presentation of one's work to a professional or non-professional audience in English and understand the language and proposals of other specialists.
- Manage bibliographies and interpret the information in the main biological databases, and also know how to use basic ICT tools.
- Manage information and the organisation and planning of work.
- Read specialised texts both in English and one's own language.
- Take responsibility for one's own learning after receiving general instructions.
- Think in an integrated manner and approach problems from different perspectives.
- Understand the language and proposals of other specialists.
- Use ICT for communication, information searching, data processing and calculations.

Learning Outcomes

1. Analyse databases on enzymes and microorganisms used in biotechnological processes.
2. Apply the criteria for the scaling and development of biotechnological processes within economic parameters.
3. Be able to self-evaluate.
4. Collaborate with other work colleagues.
5. Combine research and and the generation of knowledge with problem-solving in one's own field, showing sensibility to ethical and social questions.
6. Describe models that allow cell growth to be explained and predicted and the basic kinetic and stechiometric equations to be deduced.
7. Describe the basic concepts of intellectual and industrial property in relation to biotechnological products.
8. Describe the characteristics and applications of enzymes, immobilised biocatalysts and enzyme-based biosensors.
9. Describe the design, control and functioning of bioreactors.
10. Describe the elements of a biotechnological process, products of interest in biotechnology and the sources of these.
11. Describe the principles behind the research, development and production of biopharmaceutical products.
12. Design a basic protocol for industrial-scale processing and purification of a biotechnological product.
13. Design strategies for the production and improvement of drugs and foods using biotechnological methods.
14. Determine the properties and biotechnological applications of enzymes from extremophile organisms.
15. Display a good overall understanding of the types of companies devoted partially or completely to biotechnology.
16. Explain the basic operations and equipment used in the industrial-scale processing and bioseparation of biotechnological products.
17. Explain the design, industrial production and applications of enzymes in biotechnological processes.
18. Explain the quality assurance criteria for obtaining biotechnological products.
19. Explain the use of microorganisms in fermentations, biofuel production, biopolymers, lixiviation, bioremediation and waste-water treatment.
20. Identify the criteria of biotechnological risk assessment.
21. Interpret the laws and regulations governing the development of new biopharmaceutical products.
22. Know and interpret the characteristics of public policies for promoting biotechnology in Spain and the rest of Europe.
23. Make an oral, written and visual presentation of one's work to a professional or non-professional audience in English and understand the language and proposals of other specialists.
24. Manage information and the organisation and planning of work.

25. Read specialised texts both in English and one's own language.
26. Recognise the ethical, social and environmental issues surrounding professional activity in the field of biotechnology.
27. Take responsibility for one's own learning after receiving general instructions.
28. Think in an integrated manner and approach problems from different perspectives.
29. Understand the language and proposals of other specialists.
30. Understand the techniques used in the genetic manipulation and selection of microorganisms and eukaryotic cells, in order to use them in biotechnological processes.
31. Use ICT for communication, information searching, data processing and calculations.
32. Use computer programmes for the design and simulation of bioreactors.

Content

THEORY

PART I. INTRODUCTION

1. Introduction to Biotechnology. History of Biotechnology. Definitions of Biotechnology. Traditional biotechnology and modern biotechnology. Historical milestones. Elements of the biotechnological process: raw materials, biological agents and products.

2. Economic and social importance of biotechnology. Products of industrial interest - Potential of Biotechnology. Examples: food, energy, health - Industrial sectors - Business sectors - Protection of intellectual property - Public R & D programs in biotechnology - Biotechnology: perspectives and questions.

PART II. THE BIOTECHNOLOGICAL PROCESS

3. Raw materials. Natural raw materials. Byproducts. Petroleum derivatives. Selection and pretreatment. Examples.

4. Biocatalysis. Biocatalysts - Characteristics of enzymes as biocatalysts - Advantages of using enzymes as biocatalysts - Criteria for the efficiency of enzymes - Strategies for the development of efficient enzymes - Industrial enzymes - Industrial applications of enzymes: food, textiles, paper, detergents, pharmaceutical industry - Disadvantages of using enzymes as biocatalysts.

5. Immobilized biocatalysts (I). Concept, characteristics and industrial utility - Types of immobilization supports - Immobilization methods - Types of bioreactors for immobilized biocatalysts.

6. Immobilized biocatalysts (II). Properties of immobilized enzymes - Substrate specificity - Immobilization effects on enzyme activity and kinetic properties: partition and diffusion rate - Advantages and disadvantages of immobilization of enzymes - Industrial applications of immobilized enzymes - Immobilized cells .

7. Microbial cells (I). Microorganisms of industrial interest - Advantages of microorganisms Elemental composition ofmicroorganisms and culture media - Obtaining, selection and conservation of microorganisms - Collections of type strains.

8. Microbial cells (II). Genetic manipulation and metabolic engineering of microorganisms - Improvement of strains by mutagenesis, gene recombination and recombinant DNA techniques.

9. Fermentations. Concept of fermentation - Operating regimes - Batch, fed-batch, continuous and perfused fermentation - Solid state fermentation- Kinetics of the growth of a discontinuous culture- Kinetic parameters: specific growth rate (μ_m) and Monod constant (K_S), Yield ($Y_{X/S}$), Metabolic quotient (q_S) - Factors affecting growth rate - Kinetics of product formation - Primary and secondary metabolism products - Product yield ($Y_{P/S}$).

10. Continuous fermentation. Advantages and disadvantages of continuous fermentation. Type of continuous fermentation: chemostat and turbidostat. Balance of cell material. Dilution rate (D). Extinction of culture by dilution: wash-out. Balance of nutrient limiting material. Productivity. Enrichment. Contamination.

PART III. BIOREACTORS

11. Bioreactor design. Concept of bioreactor. Type of bioreactors. Working scales. Elements of a bioreactor. Requirements of industrial bioreactors. Auxiliary facilities.

12. Operation of a bioreactor. Aseptic operations. Aseptic inoculation and sampling. Seals and valves. Measurement and control of fermentation conditions: temperature, pH, dissolved oxygen concentration (DO), foaming, consumption and formation of gases and products. Respiratory quotion (RQ). Computer control of the bioreactor. Study of the typical fermentation profile.

13. Sterilization of the bioreactor and culture media. General considerations. Sterilization of the culture medium. Methods of sterilization. Heat sterilization. Theory of heat sterilization. Calculation of the duration of media sterilization. Continuous sterilization. Sterilization by filtration. Air sterilization.

14. Aeration of the bioreactor. General considerations. Transfer of gas-liquid matter. Specific rate of oxygen uptake. Critical oxygen concentration (C_{CRIT}). Oxygen transfer rate. Considerations that affect the oxygen transfer rate. Experimental determination of k_{La}. Elements used in aeration: types and efficiency. Hold-up: concept and distribution in stirred bioreactors.

15. Stirring of the bioreactor. Geometry and types of agitators. Required power for stirring: power number and Reynolds number. Power required for stirred and aerated bioreactors: aeration number. Power required for stirring and aeration of Newtonian and non-Newtonian fluids.

PART IV. BIOTECHNOLOGICAL PRODUCTS

16. Bioseparations. Processing of fermentation products. Process design and scale changes. Cost evaluation of the process according to the purity and performance requirements. Design of industrial type appliances and applications. Homogenization. Centrifugation. Filtration. Chromatography. Dehydration. Freeze-drying.

17. Production of enzymes on an industrial scale. Inactivating agents of the enzymes. Stabilization of enzyme preparations. Additives. Effect of ions. Evaluation of quality and safety of enzyme preparations.

18. Biological products of industrial interest. Products of primary and secondary metabolism. Production of ethanol, acetone-butanol, glycerol, lactic acid and glutamate.

19. Production of antibiotics. Main antibiotic types. Natural and semi-synthetic antibiotics. Mechanisms of resistance to antibiotics. Penicillin production.

20. Products of the food and beverage industry. Introduction to the production of food and fermented beverages. Authorized microorganisms (GRAS). Biochemistry of the production of alcoholic beverages. Biochemistry of the production of lactic and meat products. Biochemistry of bread fermentation. Biochemistry of food additives. Quality assurance.

21. Products of agriculture and livestock. Transgenic plants. Resistance of plants to herbicides, pesticides, insects and extreme environmental conditions. Bioinsecticides. Improvement of the product final quality. Transgenic animals as bioreactors. Application to the production of milk and pharmaceutical drugs.

SEMINARS

Proposed topics:

1. Biosensors. Concept. Structure and operation. Types: electrochemical, redox, FET, thermometric, optical, immunosensors. Biochips. Applications in clinical, agri-food sector and environmental control.

2. Biological purification of wastewater. Aerobic and anaerobic processes. Biological oxygen demand (BOD). Wastewater treatment: treatment plant scheme. Phases of treatment. Settling and activated sludge. Composting.

3. Bioenergy. Biomass as a source of renewable resources. Ethanol production. Raw Materials. Production of methane (biogas). Anaerobic digestion. Hydrogen production.

4. Biomining and bioremediation. Metal leaching. Oil degradation and heavy metal recovery.

5. Proteins and enzymes of extremophile organisms of industrial interest. Psychrophiles. Thermophiles and hyperthermophiles. Halophiles. Acidophiles and alkalophiles. Industrial applications.

6. Biopolymers. Classification. Microbial polysaccharides. Dextrans. Polyhydroxyalkanoates. Polyhydroxybutyrate (PHB). Biodegradable plastics. Industrial applications.

7. Quality assurance and control in biotechnological products. Good laboratory practices (GLP) and good manufacturing practices (GMP). Standard operating procedures (SOP). ISO9000 standard. Quality assurance and auditing unit. Development of new pharmaceutical drugs. Phases of R & D and pre-clinical. Clinical trials in humans.

8. Release of genetically manipulated organisms into the environment. Controlled release: field tests. Environmental impact. "Suicidal" organisms. Genetic or molecular labeling methods. Biosecurity. Risk evaluation. Regulations. Labeling.

9. Patents in Biotechnology. Conditions of patentability. Procedure for patent filing. Patentability of genes and organisms. Examples of important patents and patent "wars". Economic impact. Leading companies in patent benefits.

10. Bioethics and Legislation in Biotechnology. Medical, social and economic impact of biotechnology. Biotechnology practices posing ethical-social problems. Information derived from the Human Genome project. Gene and cell therapy. Stem cells. Use of embryos for biomedical research. Transplantation of embryonic cells. Xenotransplantation. Tissue generation from stem cells. Bioethics Committees. Regulations, recommendations and legislation.

Methodology

The subject of Industrial Biochemistry consists of theoretical classes, a public presentation of subjects related to the subject, and tutorials. The training activities of the subject are complemented by the delivery of work by the Virtual Campus and individual participation through virtual forums in debate and opinion on issues related to biotechnology.
For the public presentation of subjects or seminars, the class group will be divided into two subgroups (maximum 30 students per subgroup), whose lists will be made public at the beginning of the course. There will be 10-15 sessions of seminars during the course where students will present the proposed self-learning work (see contents of the seminars). Presentations, in PowerPoint format and a summary of a maximum page that includes the bibliography consulted, will have to be sent to the teacher a week before through the Virtual Campus. The teacher may suggest changes or modifications during that week that must be included in the presentation.

Teachers will dedicate approximately 15 minutes of a class to allow their students to answer the evaluation surveys of the teaching performance and evaluation of the subject or module.

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			
Public presentation of subjects related to the subject	15	0.6	1, 2, 31, 4, 30, 9, 7, 10, 11, 8, 6, 14, 13, 17, 18, 19, 24, 20, 21, 25, 28, 26, 5, 23, 32
Theory Classes	30	1.2	1, 2, 31, 30, 15, 9, 7, 10, 11, 8, 6, 22, 14, 13, 12, 17, 18, 19, 16, 20, 21, 28, 26, 5, 32
Type: Supervised			
Preparation of public presentations	22.5	0.9	1, 2, 31, 4, 30, 9, 7, 10, 11, 8, 6, 14, 13, 17, 18, 19, 24, 20, 21, 25, 28, 26, 5, 23, 27, 32
Tutoring	7.5	0.3	1, 2, 31, 4, 30, 15, 9, 7, 10, 11, 8, 6, 22, 14, 13, 12, 17, 18, 19, 16, 24, 20, 21, 25, 28, 26, 5, 23, 27, 3, 32
Virtual forum	4.5	0.18	1, 2, 31, 30, 15, 9, 7, 10, 11, 8, 6, 22, 14, 13, 12, 17, 18, 19, 16, 24, 20, 21, 25, 28, 26, 5, 23, 27, 32
Type: Autonomous			
Self study and autonomous activities	48	1.92	1, 2, 31, 30, 15, 9, 7, 10, 11, 8, 6, 22, 14, 13, 12, 17, 18, 19, 24, 20, 21, 25, 28, 26, 5, 27, 3, 32

Assessment

Evaluation

The assessment system consists of: 1) Partial written tests, consisting of short / medium development questions 2) Evaluation of the public presentation of subjects related to the subject (Seminars) 3) Assessment of participation in the Virtual Campus according to the number, frequency and quality of the contributions.

Resolution of theoretical questions (7.5 / 10)

The evaluation of this activity is done through two partial written tests, in which the student must demonstrate the degree of achievement of the theoretical-practical concepts of the subject.

- The partial tests, scheduled throughout the semester, evaluate the contents of each of the two parts in which the course is divided and each has a weight of 37.5% in the overall grade. These tests may eliminate material from the final exam as long as a grade equal to or higher than 3.5 has been obtained. Likewise, in the final exam it will be necessary to obtain a grade equal to or higher than 3.5 in each of the two parts in order to average the rest of the grades.

- The test or examination of recovery is carried out at the end of the semester. This test can be done by students who have not passed one or more partial tests or want to improve the corresponding qualifications. The accomplishment of this new test supposes the resignation to the first qualification.

- The activities Seminars and Virtual Campus are NOT recoverable.

- The date, time and place of the tests can be consulted with sufficient anticipation in the Virtual Campus of the subject or on the website of the Faculty.

Evaluation of seminars (2.0 / 10)

In this activity, the degree of achievement that the student has of the topics proposed by the teacher and related to the subject is evaluated. The oral presentation and discussion of the subject presented by the student will be valued. The note will be awarded the same for all the members of the group, as long as all of them have prepared and exhibited in an equivalent way. The participation (questions, interventions, debate, etc.) of the students attending the presentation of the seminars will also be valued. There will be a question about the content presented in the seminars to the final test of recovery.

- Students can present their seminar in English. This concept will be valued with 0.5 points in the final grade of the seminars.

- Participation in the seminars is mandatory, both on the day of the presentation and the attendance at the other seminars of the peers. Any lack of assistance not documented justified will be penalized on the final note of seminars.

The date, time, place of the tests can be consulted sufficiently in advance on the Virtual Campus of the subject or on the website of the Faculty.

Evaluation by the Virtual Campus (0,5 / 10)

Periods will be proposed periodically on issues related to the subject. The student will send their contributions through the file delivery tool of the Virtual Campus.

- To participate in the recovery, the students must have been previously evaluated in a series of activities whose weight equals to a minimum of two thirds of the total grade of the subject. Therefore, students will obtain the "Non-Appraising" qualification when the assessment activities carried out have a weighting of less than 67% in the final grade

The repeating students from the second matricula of the subject will not have to carry out the educational activities or the evaluations of those competitions surpassed with a note superior to 5, consisting of the seminars and the contributions through the Virtual Campus

B/ Single assessment

The single assessment consists of a single examination assessing the contents of the entire content of subject. The test will consist of short/medium development questions and an optionalquestion about the topics of seminars presented by the students.

The mark obtained in this synthesis test will represent 75% of the final grade of the subject.

The single assessment examination will be held on the same day, time and place as the last continuous assessment examination. The single assessment can be recovered on the day set for the recovery of the subject.

To 75% of the theory grade will be added 20% corresponding to the presentation grade of the seminar that the student will have previously presented in class during the semester and 5% corresponding to the deliveries by the CV.

It is necessary to obtain a final grade equal to or greater than 5 to pass the subject.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Partial and final tests of theory	75%	4	0.16	1, 2, 31, 30, 15, 9, 7, 10, 11, 8, 6, 22, 14, 13, 12, 17, 18, 19, 16, 24, 20, 21, 25, 28, 5, 23, 27, 32

Seminars	20%	14.5	0.58	1, 2, 31, 4, 30, 9, 7, 10, 11, 8, 6, 14, 13, 29, 17, 18, 19, 24, 20, 21, 25, 28, 26, 5, 23, 3, 32
Virtual Campus	5%	4	0.16	2, 31, 30, 15, 9, 7, 10, 11, 8, 6, 22, 14, 13, 12, 17, 18, 19, 16, 20, 21, 25, 5, 32

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Software

No specific software will be used in this course.