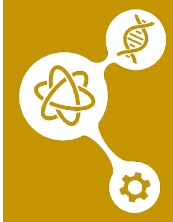
Academic year
2026/2027

Course Guide:

BIOPROCESS ENGINEERING



FACULTY OF
CHEMICAL SCIENCES

1. IDENTIFICATION

Degree Programme	Bachelor's Degree in Chemical Engineering			Course Code	801566
Course Name	Bioprocess Engineering			ECTS	6
Subject Area	Industrial Bioprocesses				
Module	Chemical Technology				
Course Type	Optional	Year	Fourth Year	Semester	First Semester
Department	Chemical and Materials Engineering				

Teaching Staff

Activity	Lecturer	Email	Office
Lectures/Seminars/Tutorials	MERCEDES MARTÍNEZ RODRÍGUEZ	mmr1@quim.ucm.es	QA-B71
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Lectures/Seminars/Tutorials	JUAN MANUEL BOLIVAR BOLIVAR	juanmbol@ucm.es	QA-B70B

QAB63 Laboratory

Group	Lecturer	Email	Office
1 and 2	ABDERRAHIM BOUAID BOUAID	babderra@ucm.es	QA-B71A

2. OBJECTIVES

General objective

Know, understand and design the different stages that constitute a bioprocess.

Specific objectives

- Know and understand the different stages that make up a biotechnological process.
- Describe and dimension sterilization processes.
- Describe and design separation operations for the isolation of insoluble and soluble products in a biotechnological process.
- Describe and size different basic operations for the purification of biotechnological products, based on chromatography and membranes.
- Describe and understand different finishing operations such as freezing and freeze-drying.
- Describe packaging methods.
- Know and understand the concept of GMP, quality and validation of biotechnological processes.
- Identify the phenomena and determining variables in the rates of biotransformations.
- Determine the appropriate kinetic model for enzymatic and microbial transformations.
- Know the different methods of immobilization of biocatalysts and their applications.

- Know the general methodology of bioprocess development.
- Know and determine the rate of oxygen transfer in aerobic transformations.
- Determine the rate of oxygen consumption in aerobic transformations.
- Know and identify the phenomenon of cellular stress.
- Know the different types of bioreactors, their modes of operation and their applications.
- Design stirred tank bioreactors in batch, semi-continuous and continuous operation.
- Know the scale change methodologies in bioprocesses.

3. PRIOR KNOWLEDGE AND RECOMMENDATIONS

Prior knowledge

To follow this course properly, students are expected to have previously acquired the knowledge and skills corresponding to the following courses: Chemical Reaction Engineering and Introduction to Biochemistry. Although enrolment is not formally conditioned by this prior learning, a sound command of this prior knowledge is essential for students to follow and benefit from the course adequately.

Recommendations

Students are advised to have a basic level of English that enables them to consult bibliography in English, search for information, and communicate both in writing and orally in that language. They are also expected to be familiar with computer tools and software for solving complex problems, as well as with applications for writing, editing, and presenting technical reports. To benefit more fully from the course, students are also advised to take the Industrial Biochemistry course.

4. CONTENTS

Brief description

Theory and practice of typical operations of biotechnological processes. Design of the equipment where these operations can be carried out. Analysis of reactions with biocatalysts (enzymes and cells). Analysis and design of mechanically stirred bioreactors using various modes of operation.

Course syllabus

1. General scheme of bioprocesses. Stages. Classification of basic biotechnological operations. Phenomenology of biotechnological transformations. Classification of biotechnological transformations. Types of bioreactors. Scale-up.
2. Phenomenological analysis of enzymatic processes. Kinetics. Immobilization methods.
3. Enzymatic reactors. Analysis and design of enzymatic bioreactors. Modes of operation. Scale-up.
4. Phenomenological analysis of processes with cells. Process development. Kinetic models. Gas-liquid transport. Cellular stress.
5. Analysis and design of bioreactors. Types and modes of operation. Scale-up.
6. Sterilization. Characteristic parameters. Methods. Design of thermal sterilization cycles. Scale-up. Sterilization by other physical means: filtration, radiation. Sterilization with chemical agents.
7. Isolation operations. Mechanical separation operations for insoluble products. Separation efficiency. Release of intracellular products, cell rupture and homogenization. Isolation of soluble products, precipitation, extraction and leaching.

8. Purification operations. Types of chromatography. Modelling. Preparative column chromatography and scale-up Operations with membranes. Classification. Ultrafiltration, reverse osmosis, pervaporation and dialysis.
9. Finishing operations. Freezing. Principles, methods and equipment. Freeze drying. Stages and equipment. GMP (Good manufacturing practice) concept. Quality control and validation of biotechnological processes.

5. COMPETENCES

General competences

CG1-TQ1	Use concepts for the autonomous learning of new methods and theories.
CG1-TQ2	Design and manage applied experimentation procedures, especially for the determination of thermodynamic and transport properties, and for the modeling of phenomena and systems in the field of chemical engineering, systems involving fluid flow, heat transfer, mass-transfer operations, chemical reaction kinetics, and reactors.
CG4-TQ1	Apply concepts of biotechnology, mass transfer, separation operations, and chemical reaction engineering. Evaluate the transformation of raw materials and energy resources.
CG5-TQ1	Analyse, design, simulate and optimise processes and products.

Specific competences

CE20-BI5	Explain the sequence of stages in a bioprocess.
CE20-BI6	Design the equipment in which to carry out the typical separation stages of a biotechnological process by applying the fundamentals of mass transfer, heat transfer, and fluid flow.
CE20-BI7	Formulate and calculate the kinetic parameters of kinetic models for systems using biocatalysts.
CE20-BI8	Calculate the basic design parameters of bioreactors.
CE20-BI9	Analyse the behaviour of bioreactors.

Cross-cutting competences

CT1-TQ1	Develop analytical and synthetic skills.
CT2-TQ1	Solve problems in the area of Chemical Technology.
CT4-TQ1	Communicate in Spanish using standard audiovisual media.
CT5-TQ1	Consult, use and analyse bibliographic sources in the area of Chemical Technology.
CT5-TQ2	Consult, use and analyse specialised databases and resources accessible through the Internet.
CT6-TQ1	Use computer tools and programs to calculate, simulate, and approximate.
CT8-TQ1	Demonstrate capacity for critical and self-critical reasoning.
CT11-TQ1	Learn autonomously.
CT12-TQ1	Develop awareness of the social and environmental impact of engineering solutions..

6. WORKLOAD DISTRIBUTION BY ACTIVITY.

Activity	In-class (hours)	Self-study (hours)	Credits
Lectures	30	50	3.2
Seminars	15	15	1.2
Tutorials/guided work	3	4.5	0.3
Laboratories	10	7.5	0.7
Coursework and examination preparation	5	10	0.6
Total	**63**	**87**	**6**

7. METHODOLOGY

Teaching will follow a mixed methodology based on cooperative learning, collaborative learning, and independent learning. This methodology will be developed through theoretical classes, seminar classes, individual or group work, guided tutorials and practical laboratory sessions.

The course integrates the principles of green chemistry to design safer, more efficient and sustainable biotechnological processes.

The theoretical classes will be taught in a single group and will mainly consist of lectures in which the full course syllabus is presented in an orderly manner with the support of audiovisual material.

The seminars will be held in a single group and will focus on setting and solving problems previously assigned to students, involving the application of theoretical knowledge, as well as the development of complementary topics with a clearly practical orientation. Part of the material consulted will be scientific publications in English, for which it is recommended to have a basic/intermediate level of English.

The tutorials will involve guiding and supervising students' progress in their individual work, as well as resolving any questions that may arise. Tutorials 1 and 2 will consist of solving a problem using computer tools (Excel or Berkeley Madonna), for which it is recommended to have basic knowledge office software.

The practical laboratory sessions will consist of collecting experimental data and calculating the different parameters involved in the laboratory work. The critical discussion and analysis of the results obtained in each practice will constitute the fundamental part of the technical reports to be delivered in each case. Likewise, visits may be made to different facilities in which biotechnological processes are developed.

The UCM Virtual Campus will be used as an instrument to make available to students the material that will be used in theoretical classes, seminars, tutorials and laboratories, and as a means of communication between the lecturer and the students.

8. BIBLIOGRAPHY

Basic bibliography

- VERRALL, M.S. (Ed.): "Downstream Processing of Natural Products", John Wiley, New York, 1996.
- DORAN, P.M.: "*Bioprocess Engineering Principles*" 2nd Ed., Academic Press (Elsevier), 2013.
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- GOLDBERG, E. (Ed): "Handbook of Downstream Processing", Blackie Academic & Professional. London, 1997.
- AIBA, S; HUMPHREY, A.E. and WILLIS, N.F.: "Biochemical Engineering." 2nd Ed., Academic Press, New York, 1973.
- WANG, D.I.C. et al.: "Fermentation and Enzyme Technology", John Wiley, New York, 1979.
- HARRISON, R.G., TODD, P., RUDGE, S.R. and PETRIDES, D.P.: "Bioseparations Science and Engineering", Oxford University Press, New York, 2003.

Supplementary bibliography

- McCABE W.L.; SMITH, J.C. and HARRIOT, P.: "Unit Operations of Chemical Engineering", 4th Ed., McGraw Hill, Madrid, 1991.
- COULSON, J.M., RICHARDSON, J.F., BACKHURST, J.R. and HARKER, J.H.: "Chemical Engineering", Vol. II, 4th Ed., Pergamon, London, 1991. Spanish translation of the third English edition: "Ingeniería Química", Reverté, Barcelona, 1981.
- VILA JATO, J.L.: "Pharmaceutical Technology. Volume I: Fundamental aspects of pharmaceutical systems and basic operations", Síntesis, Madrid, 2001.
- RODRÍGUEZ, F.: "Food Industry Engineering. Volume II. Food processing operations", Síntesis, Madrid, 2002.
- ASENJO, J.A. AND MERCHUCK, J.C.: "Bioreactor System Design", Marcel Dekker, 1994.
- BAILEY, J.E. AND OLLIS, D.F.: "Biochemical Engineering Fundamentals", 2nd Ed. McGraw-Hill, 1986.
- BLANCH H.W. AND CLARK, D.S.: "Biochemical Engineering", Marcel Dekker, 1996.
- GARCÍA-OCHOA, F., GÓMEZ, E., SANTOS, V.E.: "Stirred Tank Bioreactors" in "Comprehensive Biotechnology", 3rd edition, Volume 2. Murray Moo-Young (ed.), Elsevier: Pergamon, 2019 pp: 270-290.

9. EVALUATION

Participation in guided tutorials and laboratory sessions is mandatory, as is at least attendance at 70% of in-person classroom activities. The final grade for the course will be obtained as a weighted average, exceeding the minimums established in each section, of the evaluations of each of the activities listed below. These criteria will be maintained in the extraordinary call.

❖ WRITTEN EXAMINATION: 70%

There will be two written midterm exams, mainly practical in nature, which will account for 70% of the overall assessment. A minimum grade of 4 out of 10 must be obtained in each partial exam in order for the two grades to be averaged. . It will be necessary to obtain a minimum grade of 4 out of 10 in the exam. This condition must be met both in the case that the evaluation is carried out through the average of the partial exams, and in the case that a single final exam is chosen. Competencies CG1-TQ1, CG4-TQ1, CG5-TQ1, CE20-BI5, CE20-BI6, CE20-BI7, CE20-BI8, CE20-BI9, CT1-TQ1, CT2-TQ1, CT8-TQ1 will be evaluated.

❖ PERSONAL WORK AND GUIDED ACTIVITIES: 15%

A set of model problems will be proposed for each part of the course, which must be submitted before discussion and resolution in the seminar classes. In addition, each student must develop personalized work throughout the course, the evolution of which will be assessed in the guided tutorials. Likewise, formative theoretical-practical tests will be carried out for continuous evaluation, discussing the results to improve student learning (feedback). All this will represent 15% of the overall evaluation. This assessment will determine the extent to which the following competences have been acquired: CG1-TQ1, CG1-TQ2, CG1-TQ3, CG4-TQ1, CG5-TQ1, CT1-TQ1, CT2-TQ1, CT4-TQ1, CT5-TQ1, CT5-TQ2, CT6-TQ1, CT8-TQ1, CT11-TQ1, CT12-TQ1.

❖ ATTENDANCE AND PARTICIPATION IN CLASSES:

In order to carry out the global evaluation of the course, the student must have participated in at least 70% of the face-to-face classroom activities (theory and seminars).

❖ PRACTICAL LABORATORY SESSIONS: 15%

Student attendance at the laboratory practical sessions will be mandatory. Assessment will take into account the student's answers to specific questions posed by the lecturer, as well as the quality of the technical report submitted. Practical laboratory sessions represent 15% of the overall evaluation. The evaluation will assess the degree to which the following competencies have been achieved: CG5-TQ1, CT1-TQ1, CT4-TQ1, CT5-TQ1, CT5-TQ2, CT6-TQ1, CT8-TQ1, CT11-TQ1, CT12-TQ1.

The grades obtained in the activities included in the course assessment, such as midterm exams, laboratory sessions, tutorials, and problem submissions, will be communicated to students sufficiently in advance of the final exam, so that they can adequately plan their study for this or other courses

Students who completed the laboratory sessions in previous academic years may request exemption from repeating them, provided that no more than two years have elapsed since they completed those sessions.

In particular, the grades for the midterm exams will be communicated within a maximum period of 20 days, except in the case of the second midterm, in which the period may be shorter to adapt to the final exam. In any case, the minimum period of ten days will be respected between the publication of the grades and the date of the final exam of the course.

The final grade will result from the weighted average of the evaluable activities. However, to pass the course it will be necessary to achieve the minimum grade established in each of them. If this requirement is not met, the final grade will be the weighted average obtained, with a maximum of 4.5 out of 10.

ACTIVITY SCHEDULE

UNIT	ACTIVITY	HOURS	GROUPS	START	END
Topic 1	Lectures	1	1	1st Week	
Topic 2	Lectures	3	1	1st Week	2nd Week
	Seminars	3	1	2nd Week	3rd Week
Topic 3	Lectures	4.5	1	3rd Week	4th Week
	Seminars	3	1	4th Week	5th Week
Topic 4	Lectures	4.5	1	5th Week	7th Week
	Seminars	3	1	7th Week	8th Week
Topic 5	Lectures	4	1	8th Week	9th Week
	Seminars	1	1	9th Week	9th Week
Topic 6	Lectures	2	1	10th Week	10th Week
	Seminars	1	1	10th Week	10th Week
Topic 7	Lectures	5	1	11th Week	12th Week
	Seminars	2	1	12th Week	13th Week
Topic 8	Lectures	4	1	13th Week	14th Week
	Seminars	2	1	14th Week	15th Week
Topic 9	Lectures	2	1	15th Week	15th Week
	Seminars				
Topics 1 to 9	Tutorials	3	1	12th Week	15th Week
Topics 1 to 9	Laboratories	10	2 or 3	6th Week	14th Week

SUMMARY OF ACTIVITIES

TEACHING ACTIVITY	ASSOCIATED COMPETENCES	TEACHING ACTIVITY	STUDENT ACTIVITY	EVALUATION	P	NP	TOTAL	C
Lectures	CE20-BI5, CE20-BI6, CE20-BI7, CE20-BI8, CE20-BI9, CT1-TQ1	Verbal presentation of the main lines of each topic of the programme	Attention and active participation in the development of the class.	Written exams	30	50	80	
Seminars	CG1-TQ2, CG1-TQ3, CG4-TQ1, CG5-TQ1, CT1-TQ1, CT2-TQ1, CT4-TQ1, CT8-TQ1	Formulation and resolution of numerical questions and problems.	Discussion and resolution of the proposed exercises and problems	Assessment of the resolution and discussion of the proposed exercises and problems	15	15	30	
Tutorials/guided work	CG1-TQ2, CG1-TQ3, CG4-TQ1, CG5-TQ1, CE20-B19, CT1-TQ1, CT2-TQ1, CT4-TQ1, CT8-TQ1, CT12-TQ1, CT11-TQ1	Monitoring students' progress in their personal work	Development of your individual work	Assessment of the work carried out by the student in the development of the proposed personal work	3	4.5	7.5	**15%**
Practical laboratory sessions	CG1-TQ2, CG1-TQ3, CG4-TQ1, CG5-TQ1, CE20-B17, CT1-TQ1, CT2-TQ1, CT4-TQ1, CT8-TQ1, CT11-TQ1, CT12-TQ1	Explanation and supervision of the laboratory work	Collection, analysis and discussion of experimental data to calculate the different parameters. Preparation of the technical report on the laboratory work	Assessment of the student's work during the laboratory session and of the technical repor.	10	7.5	17.5	**15%**
Exams	CG4-TQ1, CG5-TQ1, CT2-TQ1, CT8-TQ1	Design and correction of the exam. Student Grade	Taking the exam	Exam	5	10	15	**70%**

P: In-class activities

NP: Non-classroom activities (self-study)

C: Assessment weighting