COURSE PROGRAM

Identification and characteristics of the course				
Code	401365	ECTS Credits	6	
Course name (English)	Enzyme Biotechnology			
Course name (Spanish)	Biotecnología de Enzimas			
Degree programs	Master's Degree in Advanced Biotechnology			
Faculty/School	Faculty of Science			
Semester	6	Type of course	Optional	
Module	Cellular and Molecular Biotechnology			
Matter	Enzyme Biotechnology			
Lecturer/s				
Name	Office	E-mail	Web page	
Martínez de Alba, Ángel Emilio	DBQ5	aemarti@unex.es	https://bit.ly/AEMAResearch	
Benítez López, Dixan Benítez	DBQ2	benitezlda@unex.es	https://bit.ly/3OSRTVU	
Subject Area	Biochemistry and Molecular Biology			
Department	Biochemistry and Molecular Biology and Genetics			
Coordinating Lecturer (If more than one)	Ángel Emilio Martínez de Alba			

Competencies/Learning Outcomes*

1. Core Competences (CB)

CB6 - Possess and understand knowledge that provides a basis or opportunity for originality in the development and/or application of ideas, often in a research context.

CB7 - Students are able to apply their acquired knowledge and problem-solving skills in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.

CB8 - That students are able to integrate knowledge and deal with the complexity of making judgements based on incomplete or limited information, including reflections on the social and ethical responsibilities linked to the application of their knowledge and judgements.

CB9 - Students are able to communicate their conclusions and the knowledge and rationale underpinning them to specialist and non-specialist audiences in a clear and unambiguous way.

CB10 - That students possess the learning skills that will enable them to continue studying in a largely self-directed or autonomous manner.

2. General competences (GC)

GC1 - Ability to successfully follow postgraduate courses that specifically qualify them in teaching, research or professional fields.

* The sections concerning competencies, course outline, educational activities, teaching methodologies, learning outcomes and assessment systems must conform to that included in the ANECA verified document of the degree program.

GC2 - Ability to autonomously generate, acquire and process information related to Biotechnology.
GC3 - Ability to plan, execute and criticise knowledge processes in the field of their activity.
GC4 - Ability to apply knowledge of basic sciences and technologies to biological and health systems.
GC5 - Ability to identify, formulate and solve problems within broad, multidisciplinary contexts, by integrating knowledge and participating in multidisciplinary teams.
GC6 - Ability to analyse and assess the social and environmental impact of technical solutions, understanding ethical and professional responsibility in the field of Biotechnology.
GC7 - Ability to solve problems with initiative, decision-making, autonomy and creativity.

3. Transversal competences (TC)

TC1 - Apply the knowledge acquired in the degree to work in a professional and rigorous manner, as well as perform safely in a laboratory.
TC2 - Use and apply information and communication technology (ICT) in the training and professional field.
TC3 - Possess and understand information from advanced textbooks and access knowledge from the forefront of the field of study of the degree.
CT4 - Develop learning, organisation and planning skills, necessary both for undertaking further studies with a high degree of autonomy and for professional performance.
CT5 - Interpret, analyse and synthesise relevant data and information that enable students to develop ideas, solve problems and issue critical reasoning on important social, scientific or ethical issues.
CT6 - Effectively transmit results and conclusions to both specialised and non-specialised audiences.
TC7 - Express oneself correctly in writing and orally in one's native language, as well as sufficiently mastering a foreign language, preferably English.
CT8 - Lead or work in a team, adapting positively to different contexts and situations.
CT9 - Respect fundamental rights and equality between men and women, as well as acquiring an ethical commitment to respect life and the environment.

4. Specific competences (SC)

SC6 - Acquiring a command of the advanced terminology commonly used in Biochemistry and Molecular Biology, Genetics, Cellular and Tissue Biology, Microbiology, Ecology, Soil Science, and Animal and Plant Physiology.
SC7 - Knowledge of advanced analytical, experimental and computer techniques common in Biochemistry and Molecular Biology, Genetics, Cell and Tissue Biology, Microbiology, Ecology, Soil Science, and Animal and Plant Physiology.
CE8 - Advanced knowledge of selective and controlled manipulation of cellular and biomolecular processes to generate new biotechnological products.
SC12 - Analyse, model, and calculate biological systems using matter and energy balances and molecular mechanisms, both in stationary and non-stationary regimes, and identify their applications.

Contents

Course outline*

Enzyme Biotechnology provides basic concepts necessary for the manipulation of enzymes and the optimisation of enzymatic processes. This course contributes to the student's knowledge and

understanding of the fundamental concepts of enzyme kinetics. This course deals with the structures of the two groups of biocatalysts, proteins and nucleic acids, which participate in complex enzyme kinetics. This course studies the kinetic characterisation of enzyme activities and the behaviour of compounds that activate and inhibit the action of enzymes, allosterism, as well as the obtaining, production and purification of enzymes. The effect of environmental factors on enzyme catalysis and how enzymes can be optimised for use in biotechnological applications are discussed, including the preparation of immobilised enzymes and the development of biosensors and bioproduction using enzyme bioreactors. Finally, enzyme applications in the food, pharmaceutical and chemical industries are presented.
Course syllabus
Name of lesson 1: Biocatalyst concept Contents of lesson 1: Similarities and differences between bio- and chemo-catalysts. Potentiality of biocatalysts. History of Enzyme Technology/Applied Biocatalysis. Advantages and disadvantages of enzyme-based production processes. New enzyme-based processes. Description of the practical activities of lesson 1: Not applicable.
Name of lesson 2: Enzymatic catalysis Contents of lesson 2: General properties of enzymes. Classification. Specificity. Enzyme cofactors. Activation energy. Catalytic mechanisms: acid-base catalysis, covalent catalysis. Metallic cofactors. Proximity and orientation effects. Transition state. Catalytic antibodies. Description of the practical activities of lesson 2: Practical exercise 1. Development of enzyme activity measurement procedures.
Name of lesson 3: Enzyme kinetics Contents of lesson 3: Chemical kinetics. Enzyme kinetics: Michaelis-Menten equation. Reactions with two substrates: single displacement and double displacement (ping-pong) reactions. Determination of the bisubstrate mechanism by kinetic measurements. Description of the practical activities of lesson 3: Practical exercise 2. Enzyme kinetics and inhibition.
Name of lesson 4: Enzyme inhibition Contents of lesson 4: Competitive, acompetitive, non-competitive and mixed inhibition. Irreversible inhibitors. Description of the practical activities of lesson 4: Practical exercise 3. Effect of temperature on enzyme activity.
Name of lesson 5: Enzyme activity control Contents of lesson 5: Allosteric control of enzyme activity. Allosteric inhibition of aspartate transcarbamylase. Regulation by covalent modification. Regulation by proteolytic cleavages. Description of the practical activities of lesson 5: Not applicable.
Name of lesson 6: Enzyme reaction mechanisms Contents of lesson 6: Proteases: mechanism of action of chymotrypsin. Serine proteases. Other proteases. Protease inhibitors. Restriction enzymes. Description of the practical activities of lesson 6: Not applicable.
Name of lesson 7: Effect of environmental factors on enzyme activity Contents of lesson 7: Effect of pH on enzyme activity. Effect of dielectric constant. Effect of temperature on enzyme activity and stability. Influence of ionic strength. Enzymatic processes in non-conventional solvents. Description of the practical activities of lesson 7: Practical exercise 4. Effect of substrate and pH on enzyme activity.

Name of lesson 8: Production and purification of enzymes of biotechnological interest.
Contents of lesson 8: Sources of enzymes. Enzyme production process. Preparative chromatographic techniques for enzyme purification. Preparation of enzymes for commercialization.
Description of the practical activities of lesson 8: Not applicable.

Name of lesson 9: Enzyme applications in solution
Contents of lesson 9: Areas of application. Advantages and disadvantages of its use. Design of the medium. Productivity of a biocatalyst in solution. Example applications of enzymes in solution. Biotechnological applications of carbohydrases. Biotechnological applications of proteases. Biotechnological applications of lipases. Enzymatic detergents.
Description of the practical activities of lesson 9: Not applicable.

Name of lesson 10: Enzyme immobilization and applications
Contents of lesson 10: Principles of enzyme immobilization. Types of enzyme immobilization. Types of supports. Methods of enzyme-support binding: Immobilization by adsorption; Immobilization by entrapment; Ionotropic immobilization; Immobilization by encapsulation. Kinetics of immobilized enzymes. Partition effects. Diffusional effects. Applications of immobilized enzymes: Immobilization of glucose isomerase; Immobilization of amino acid acylase; Immobilization of lactase; Immobilization of lipases.
Description of the practical activities of lesson 10: Not applicable.

Name of lesson 11: Applied biocatalysis
Contents of lesson 11: Starch processing. Production of glucose-fructose syrup. Obtaining biofuel from biomass. Production of ethanol from starch. Obtaining biofuel from lignocellulose. Use of enzymes in the food industry. Use of enzymes in the detergent industry. Enzyme applications in the textile industry.
Description of the practical activities of lesson 11: Not applicable.

PRACTICAL TRAINING PROGRAMME
1. Development of enzyme activity measurement procedures.
2. Enzyme kinetics and inhibition.
3. Effect of temperature on enzyme activity.
4. Effect of substrate and pH on enzyme activity.

Educational activities *

Student workload in hours by lesson		Lectures	Practical activities				Monitoring activity	Homework
Lesson	Total	L	HI	LAB	COM	SEM	SGT	PS
1	4	1						3
2	11	4		3				4
3	13	4		3				6
4	12	4		3				5
5	11	4						7
6	11	4						7
7	13.5	4		3.5				6
8	10	3						7
9	14	3				2		9
10	16	4				3	1	8
11	12.5	3				2.5	1	6
Assessment **	22	2						20
TOTAL	150	40		12.5		7.5	2	88

L: Lectures (100 students)
HI: Hospital internships (7 students)
LAB: Laboratory or field practices (15 students)
COM: Computer room or language laboratory practices (20 students)
SEM: Problem classes or seminars or case studies (40 students)
SGT: Scheduled group tutorials (educational monitoring, ECTS type tutorials)
PS: Personal study, individual or group work and reading of bibliography

Teaching Methodologies*

1. Lectures on content Explanation and discussion of content.
2. Problem solving, analysis and discussion. Carrying out, presentation and defence of work/projects.
3. Learning through experimentation. Description: teaching-learning method based on the scientific method in which the student raises hypotheses, experiments, collects data, searches for information, applies models, contrasts the
hypotheses and draws conclusions.
4. Individual or group monitoring of learning activities.
5. Autonomous work by the student.

Learning outcomes *

To understand the kinetic bases of complex biocatalytic processes. To be able to establish the strategy and determine the methodologies to be used to obtain and purify enzymes of biotechnological interest. Know the main types of enzyme immobilisation and establish the criteria to determine which is the most suitable for particular cases. To learn about particular cases of enzyme systems with solvents or biocatalysts that are unconventional at the biological

** Indicate the total number of evaluation hours of this subject.

level, but of great biotechnological interest. To learn about the main biotechnological applications of enzymes at an industrial level.

Assessment systems *

In accordance with the regulations on the assessment of learning outcomes and competences acquired by students in official UEx degrees (Rector's Resolution of 26/10/2020 published in DOE no. 212 of 03/11/2020), students may choose between the two assessment systems:

1st option: Continuous assessment

To opt for this type of assessment, students must attend theory classes, seminars and laboratory practice. Absences must be justified. In order to benefit from the continuous assessment, the student must have attended at least 70% of the theoretical classes, participate in the proposed activities, and it is compulsory to attend all the laboratory practice.

Exam: individual test that can take different forms (development or long answer, short answer, multiple-choice, exercises, problems, virtual self-assessments, etc.) or be a combination of these (60-100% weighting).

2. Active participation in the classroom: continuous assessment method based on the student's active participation in classroom activities (30% maximum weighting).
3. Resolution of exercises and problems: test consisting of the development and interpretation of appropriate solutions based on the application of routines, formulas or procedures to transform the information initially proposed by the teacher. This activity may be carried out in the classroom or as a non-classroom activity (30% maximum weighting).
4. Preparation of work and its presentation (case studies, projects, etc.): development of work that may range from short and simple to extensive and complex, including projects and reports typical of final year courses. This assessment activity may also include the presentation of the work to demonstrate the learning outcomes (30% maximum weighting).

In order to calculate the final grade for the course, a minimum of 4.0 must be obtained in each of the blocks. The final grade will have to be equal or higher than 5.0 out of 10 to pass the subject.

2nd option: Single global assessment

To opt for this type of assessment the student must request it in writing within the first three weeks of the semester.

This exam consists of theory questions, practical questions and theoretical and/or numerical questions.

Structure of the exam:

a) Written test: multiple-choice questions on all the topics, to assess the understanding of all the concepts explained (70% maximum of the final grade).

b) Short written test which may include one or more problem-type questions or questions related to the whole subject, including laboratory practice (maximum 30% of the final grade). In order to pass the course, a minimum of 5 points out of 10 will be required.

The grading system in force at any given moment will be applied; currently, the one that appears in RD 1125/2003, article 5. The results obtained by the student in each of the subjects of the syllabus will be graded according to the following numerical scale from 0 to 10, to one decimal place, to which the corresponding qualitative grade may be added: 0 - 4.9: Fail (SS), 5.0 - 6.9: Pass (AP), 7.0 - 8.9: Good (NT), 9.0 - 10: Outstanding (SB). The mention of Honours Degree may

be awarded to students who have obtained a grade equal to or higher than 9.0. Their number may not exceed 5% of the students enrolled in a subject in the corresponding academic year, unless the number of students enrolled is less than 20, in which case only one Honours Degree may be awarded.

Bibliography (basic and complementary)

No specific textbook will be used for the development of the subject. The following is a list of recommended texts of a general nature.

Mathews, C.K., Van Holde, K.E., Appling, D.R. and Anthony-Cahill, S.J.: "Biochemistry". Pearson, 4th ed., 2013. Chapter 11: "Enzymes: biological catalysts".

Cornish-Bowden, A.: "Fundamentals of Enzyme Kinetics". Wiley-Blackwell, 4th ed. 2012.

Bisswanger, H.: 'Practical Enzymology'. Wiley, 3rd ed., 2019.

Grunwald, P.: "Biocatalysis. Biochemical Fundaments and Applications". Imperial College Press, 2009.

Chaplin, M.F. and Bucke, C.: "Enzyme Technology". Cambridge University Pres, 1990.

Smith, J.E.: "Biotechnology". Ed. Acribia, 2004.

Voet, D., Voet, J.G., and Pratt, C.W.: "Principles of Biochemistry". Editorial Panamericana, 4th ed., 2016. Part III: 'Enzymes'

Whitehurst, R.J. and Law, B.A. eds. "Enzymes in Food Technology". CRC Press, 2002.

Berg, J.M., Stryer, L., Tymoczko, J.L., and Gatto, G.J.: "Biochemistry", 8th ed., 2015. W. H. Freeman and Company, New York.

Nelson, D. L., and Cox, M., and Lehninger, M.: "Principles of Biochemistry", 7th ed., 2017. W. H. Freeman and Company, New York.

Other resources and complementary educational materials

Journals with access via Science Direct: http://www.sciencedirect.com/science/search

Journal of Molecular Catalysis B. Enzymatic.

Biotechnology Advances

Current opinion in Biotechnology

New Biotechnology

Trends in Biotechnology

Process Biochemistry

Enzyme and Microbial Technology

Journal of Biotechnology