Biocatalysis

Code: 100764
ECTS Credits: 6

2025/2026

Degree	Type	Year
Biology	OT	4

Contact

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

There are no official prerequisites. In any case, some of the contents of the 1st and 2nd year courses, Biochemistry and Biosignalling and metabolism, are necessary to follow the subject correctly.

Objectives and Contextualisation

Objectives and Contextualisation

The subject Biocatalysis focuses on the study of enzymes, their properties and applications. The knowledge of enzymes is key in the context of Biochemistry, Molecular Biology and related sciences, given their role as catalysts of biological reactions and their applications in biotechnological processes. The subject analyzes enzymes from different perspectives: their activity, kinetics, mechanisms and applications. The general objective of the subject is to provide the foundations for the analysis, characterization and use of enzymes from the point of view of research and from their biotechnological and biomedical applications.

Specific objectives of the subject:
Knowledge of the general characteristics, classification and testing methods of enzymatic activity.
Analysis of enzyme kinetics and determination and meaning of kinetic parameters.
Knowledge of enzyme inhibition and its applications, especially in the field of drugs.
Analysis of the active center and knowledge of the methods of characterization.
Analysis of enzymatic and regulatory mechanisms.
Biomedical and biotechnological applications of enzymes.

Use of software to study the structures of enzimes and modulators, as well as enzyme kinetics.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Apply statistical and computer resources to the interpretation of data.
- Be able to analyse and synthesise

- Be able to organise and plan.
- Carry out functional tests and determine, assess and interpret vital parameters.
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Obtain information, design experiments and interpret biological results.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
- Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
- Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
- Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
- Take sex- or gender-based inequalities into consideration when operating within one's own area of knowledge.
- Understand and interpret the physicochemical bases of the basic processes of living beings
- Understand the processes that determine the functioning of living beings in each of their levels of organisation.

Learning Outcomes

1. Analyse a situation and identify its points for improvement.
2. Apply statistical and computer resources to the interpretation of data.
3. Assess the suitability of the methods for determining enzyme activities and analyse the effect of the test conditions.
4. Be able to analyse and synthesise.
5. Be able to organise and plan.
6. Calculate and interpret the kinetic parameters of enzyme reactions, by means of graphic methods using computer programmes.
7. Correctly analyse data on ligand-macromolecule affinity constants and binding points.
8. Critically analyse the principles, values and procedures that govern the exercise of the profession.
9. Describe the fundamental physicochemical principles of enzyme catalysis.
10. Describe the structural bases and the principal mechanisms of enzyme catalysis and how they are regulated.
11. Identify the principal mechanisms of enzyme inhibition, know their biological significance and calculate and interpret the corresponding constants.
12. Obtain information on the structural basis of enzymes and their mechanisms from the principal databases.
13. Propose new methods or well-founded alternative solutions.
14. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
15. Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
16. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
17. Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
18. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
19. Take account of social, economic and environmental impacts when operating within one's own area of knowledge.

20. Take sex- or gender-based inequalities into consideration when operating within one's own area of knowledge.
21. Use enzyme databases to study enzyme activity, functions and applications.

Content

Theoretical topics.

Topic 1. Introduction to biocatalysis.

Concept of biocatalysis. Market and use of biocatalysts. Prejudices in the use of enzymes. Waves of innovation in biocatalysis. Advantages and disadvantages of biocatalysts Cellular and enzymatic systems: properties. Factors to consider in a biocatalysis process: source of biocatalyst and process optimization.

Topic 2. Properties, classification and nomenclature of enzymes.

General properties of enzymes: Biological, chemical and practical concept and meaning. Definitions. Enzyme-substrate complex. Decreased activation energy. Transitional state. Enzyme cofactors. Nomenclature and classification of enzymes. Databases with enzymatic information.

Topic 3. Methods for determining enzyme activity and obtaining enzymes.

Obtaining and characterizing enzymes. Sources of obtainment. Techniques for the extraction of enzymes. Enzyme purification. Analysis of the purification process. Methods for determining enzyme activity. Direct and indirect, continuous and discontinuous tests. Initial velocity: concept, determination, representation. Units of enzymatic activity. Effect of enzyme concentration.

Topic 4. Enzymatic kinetics analysis.

Enzymatic kinetics. Reactions with a substrate. Effect of substrate concentration: Michaelis-Menten equation. Prestationary state and steady state: concepts. Steady-state hypothesis: Briggs-Haldane treatment. Enzymatic reactions with more than one intermediate enzyme-substrate complex. Meaning of the kinetic parameters kcat, K_M and kcat/K_M. Determination of kinetic parameters. Methods with linear representations: Lineweaver-Burk, Eadie-Hofstee and Hanes-Woolf. Nonlinear regression. Michaelis-Menten equation for reversible reactions: Haldane relation.

Topic 5. Inhibition of enzymatic catalysis.

Inhibition of enzyme catalysis: types of inhibitors. Reversible inhibitors: competitive inhibition, aggressive and mixed inhibition (includes non-competitive inhibition). General model. Graphical analysis of the different types of inhibition. Determination of inhibition constants. Concept of IC_{50} and its relationship with inhibition constants. Inhibition due to excess substrate. Pseudoirreversible inhibitors and irreversible inhibitors. Affinity markers. Suicide inhibitors. Use of inhibitors such as medicines.

Topic 6. Analysis of enzymatic kinetics in reactions with more than one substrate.

Reactions with more than one substrate: Cleland's notation. Ordered sequential mechanism, statistical sequential mechanism, double displacement mechanism (ping-pong). Mathematical treatment and graphic analysis. Methods for determining the type of mechanism. Isotopic exchange and isotopic effect.

Topic 7. Kinetics of ephemeral or fleeting ("transient") states.

Characteristics of fast kinetic methods Mixing methods: continuous flow, stopped flow and extinct flow. Relaxation methods: temperature jump (T-jump), pressure jump (P-jump). "Bursts" and "lags". Analysis of the "Burst" of a reaction: determination of the concentration of active sites. Application of fast kinetic techniques to the N2 fixation process.

Topic 8. Effect of pH and temperature on enzymatic reactions.

Effect of temperature on enzymatic kinetics. Representation of Arrhenius. Enzymes of extremophile organisms. Effects of pH on enzyme kinetics. Influence of pH on kinetic parameters. Ionization of essential waste. Evaluation of ionization constants. Identification of ionizable groups involved in the binding and catalysis processes. Effects of the microenvironment on pK. Examples.

Topic 9. Cooperativity and allosterism.

Ligand binding to proteins. Concept and types of cooperativity. Analysis of cooperativity. Hill's equation. Models of cooperativity. Model of Monod, Wyman and Changeux. Explanation of homotropic cooperative effects by the MWC model. Allosteric enzymes. Model of Koshland, Nemethy and Filmer. General model. Example of an enzyme with allosteric regulation: aspartate transcarbamylase.

Topic 10. Enzymatic specificity.

The active site, specificity and three-dimensional structure. Definition of active centre. Characteristics of the active centre. Theories on the coupling between the enzyme and the substrate. Fisher's theory (lock and key). Koshland's theory ("induced adjustment"). Hexokinase as an example of induced coupling. Theory of conformational selection. Three-point union hypothesis. Hypotheses that imply tension. Stabilization of the transitional state. Evidence supporting the transitional state theory. Catalytic antibodies. Applications of catalytic antibodies.

Item 11. Study of the active center.

Research on the three-dimensional structure of proteins: X-rays, NMR, cryo-electron microscopy. Identification of binding and catalysis centers. Chemical modification with specific irreversible inhibitors. Affinity markers. Suicide inhibitors, examples with pharmacological interest. Directed mutagenesis. Serine proteases: subtilisin. Restriction endonucleases. "Editorial" and error-correcting mechanisms: aminoacyl-tRNA synthetases.

Topic 12. Mechanisms of enzymatic catalysis.

Catalysis mechanisms. Introduction to the mechanisms of enzymatic action. Acid-base catalysis. Triosa phosphate isomerase. Covalent catalysis. Serine proteases and aminotransferases. Catalysis with metal ions. Mechanisms of alcohol dehydrogenase and carbonic anhydrase. Effect of the environment: electrostatic catalysis. Lysozyme and superoxide dismutase. Proximity and orientation effects. Channeling intermediaries. Multifunctional enzymes. Enzymes with additional non-enzymatic functions "moonlighting enzymes".

Topic 13. Cofactors and ribozims.

Cofactors and ribozymes. Catalytic activity of RNA. Types of ribozymes. The ribosome is a ribozyme. Biological meaning of ribozymes. World of the RNA. Applications of ribozymes.

Item 14. Regulation of enzyme activity.

Regulation of enzyme activity. Modification of the enzyme concentration. Regulation of enzyme synthesis and degradation. Degradation mechanisms. Variation in enzyme rate as a function of substrate, product, and cofactor concentration. Precursor activation and retroinhibition. Functional meaning of cooperativity and allosterism. Hormonal control. Isoenzymes. Polymerization-depolymerization. Binding to other proteins. Irreversible covalent modification. Reversible covalent modification. Enzymatic cascade systems.

Topic 15. Biomedical and biotechnological applications of enzymes.

Enzymes in clinical biochemistry and biotechnology. Enzymes as therapeutic agents. Enzymes that indicate pathologies. Plasma enzymes. Factors that affect plasma enzyme levels. Examples of enzymes of diagnostic interest. Aminotransferases. Creatine kinase. Lactate dehydrogenase. Indicators of myocardial infarction. Enzymes as reagents in clinical biochemistry. Congenital enzymes and metabolism errors, examples. Enzymes in industry. Large-scale production of enzymes. Applications: medicines, food industry, detergents, textile industry. Immobilized enzymes. Enzymes as biosensors.

Item 16. Directed evolution.

Methods to improve biocatalysis. Design and synthesis of new catalysts. Directed evolution. Generation of mutants. Selection and screening of enzyme activity. Re-design of enzymes to modify their thermostability and enantioselectivity. Adaptive evolution in the laboratory.

Problem solving.

The problems are specifically focused on the analysis of enzyme activity and the determination and interpretation of kinetic parameters. The statements of the problems will be published through the Virtual Campus.

Submission of works through the Virtual Campus:

Two projects will be proposed through the Virtual Campus, which must be solved by the teams (of three/four people) formed at the beginning of the course. The works must be submitted before a specific date through the Virtual Campus tool.

Practical Laboratories (PLAB)

Organized into two 4-hour laboratory sessions, a one-hour session at the Chemical Analysis Service, and a three-hour session in the computer room. Program: Characterization of an overexpressed enzyme in yeast (*Saccharomyces cerevisiae*). Analysis of the reaction's stereospecificity toward different substrates using gas chromatography. Determination of kinetic parameters under steady-state conditions using specific software.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problems solving classes	5	0.2	7, 2, 3, 6, 11, 5, 21
Sessions of laboratory work	12	0.48	2, 3, 6, 11, 5, 21
Theory classes	35	1.4	20, 19, 8, 1, 2
Type: Supervised			
Group tutorials	2	0.08	3, 9, 10, 4
Type: Autonomous			
Problem resolution	20	0.8	7, 2, 3, 6, 9, 11, 4, 5, 21
Study	50	2	7, 8, 10, 11, 12, 4, 5, 21
Teamwork delivered through the virtual campus platform	11	0.44	12, 4, 5, 21

The subject of Biocatalysis consists of theoretical sessions, submission of assignments via the Virtual Campus, problem-solving sessions, and laboratory practicals. The following outlines the organization and teaching methodology for these activities.

Theory classes:

The theoretical content will be taught primarily through lectures supported by audiovisual materials. The presentations used in class will be made available on the subject's Virtual Campus before each topic is

introduced. These expository sessions will form the core of the theory component. It is recommended that learners access the published materials in advance to follow the sessions more effectively. To consolidate and clarify the content, it is advisable to consult regularly the recommended readings listed in the Bibliography, as well as the online resources and links provided for each topic, which include videos and animations related to the processes discussed in class.

Resolution and delivery of group work:

This activity is intended to foster teamwork skills, with individuals organized into groups in which all members are expected to actively contribute to both the writing and presentation of the work.

The methodology is as follows:

At the beginning of the course, participants will form groups of two or three, registering via the Virtual Campus before the deadline set by the teaching staff. Groups will work on assigned topics outside regular class hours. Submissions will be uploaded via the Virtual Campus. The same grade will apply to all members of each group.

Assignment instructions and deadlines will be published on the Virtual Campus.

Problem solving classes:

There will be five problem-solving sessions focusedon key problems related to the theoretical content. These sessions aim to consolidate previously introduced concepts and help familiarize participants with experimental approaches, interpretation of scientific data, and problem-solving based on real experimental situations.

Problem statements will be made available in advance on the Virtual Campus.

Laboratory practices (PLAB):

There will be two 4-hour laboratory sessions, one 1-hour session at the Chemical Analysis Service, and one 3-hour session in a computer lab, covering the following:

1. Determination of Bdh1p enzyme activity in yeast extracts (overexpressing the enzyme). Calculation of activity in U/mL against different substrates.

2. Determination of kinetic parameters of Bdh1p using acetoin as substrate. Preparation of reaction mixtures and measurement of initial velocities to calculate kinetic constants using spreadsheet software.

3. Separation and identification of substrates and products via ethyl acetate extraction and chiral column gas chromatography.

4. Use of computational tools for kinetic analysis and inhibitor characterization of Bdh1p. Structural analysis of enzymes using specific software.

Tutoring sessions.

There will be group tutoring sessions before each partial test (1and 2), and individual sessions will be available upon request. If demand is high, additional classroom-based tutorials will be scheduled and announced via the Virtual Campus. These sessions will focus on clarifying doubts, reviewing key concepts, and providing guidance on the use of scientific resources.

Materials available on the Virtual Campus:

- Presentations used during lectures
- Assignment instructions and submission portals
- Problem statements

- Practical class protocols
- Calendar of teaching activities (lectures, tutorials, assessments)

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
Continuous evaluation: two partial theory tests. Examination-based evaluation: final theory test.	60	5	0.2	20, 19, 8, 1, 3, 9, 10, 11, 13, 4
Problem-solving exam	10	2	0.08	7, 3, 6, 11, 5
Teamwork delivered through the virtual campus platform	15	0	0	20, 19, 8, 3, 12, 18, 17, 16, 14, 15, 4, 5, 21
Writing and presentation of the laboratory practices	15	8	0.32	2, 3, 6, 11, 12, 4, 5, 21

This subject includes two types of assessment: continuous and unique.

Continuous assessment.

The objective of the continuous assessment is to encourage the student's effort throughout the course, allowing them to evaluate their degree of follow-up and understanding of the subject.

Partial theory tests. Individual evaluation (6/10)

- The evaluation of this activity will be carried out through two written tests in which the student must demonstrate his degree of achievement of the theoretical concepts.

- Each of the tests will have an overall weight of 30%. The first will be scheduled in the middle of the semester and the second at the end of the semester. Both tests will include "test" questions and short questions related to theory classes.

Problem test. Individual evaluation (1/10)

On the day of the second partial theory test, three problems of the types covered through the problem classes will have to be solved. The result of this test will have an overall weight of 10%.

Submissions via the Virtual Campus. Group evaluation (1.5/10).

Two deliveries related to the content given in the theory and problems classes will be made during the course. The works prepared in groups of 2-3 people will be delivered through the Virtual Campus. For the assessment, not only the correct resolution of the work but also its approach and presentation will be taken into account. The whole group will receive the same grade. If deemed necessary, the teacher may request that a questionnaire regarding the group's work be completed individually. Although the results of this questionnaire will not initially have a specific weight in the grade of the subject, in case of detecting negative evaluations of a

person by the rest of the members of their group that show that they have not participated in thework, the qualification obtained by the group will not be applied or may be reduced.

Attendance to practical classes and completion of the corresponding report. Group evaluation (1.5/10).

The student must bring the appropriate material such as gown, protective glasses and the practice script (previously worked at home). The attitude of the student in the laboratory will be evaluated, as well as their work. The student will deliver a practice report on the day signed by the teacher in which he will have answered the questions raised. The evaluation of the attitude will represent 25% of the grade and the evaluation of the report presented, the other 75% of the total grade.

Recovery test .

Students who have not obtained a grade equal to or greater than 5, will have to take the recovery exam, in which they can choose between theory 1st partial and/or theory 2nd partial and / or problems.

The activities of deliveries of works through the virtual campus and the assistance and presentation of the memory of the practical classes are not recoverable.

Examination-based assessment.

Theory (60% of the overall grade)

Individual evaluation through:

A final test, which will be carried out at the same time as the second partial exam of the subject, in which the subject will be that of the whole subject. In this test there will be multiple choice questions and short questions. The weight of this test will be 60% of the overall grade.

Problems (10% of the overall grade).

A final test, which will be carried out at the same time as the second partial exam of the subject, in which three problems of all the subject matter of the subject must be solved. The weight of this test will be 10% of the overall grade.

Submissions through the Virtual Campus: (15% of the overall grade).

The content and rules of this section are the same as those described under the heading of continuous assessment.

Attendance to practical classes and completion of the report. Group assessment (15% of the overall grade).

The content and rules of this section are the same as those described under the heading of continuous assessment.

In all cases, in addition to knowledge, the acquisition of written communication skills will be taken into account.

Recovery test.

Students who have not obtained a grade equal to or greater than 5, will have to take the recovery exam, in which they can choose between taking a theory exam of the whole course and/or problems.

Global evaluation of the subject.

In case of continuous evaluation, the overall evaluation of the subject will include the qualifications of the two partial theory tests and the problem test, as well as the delivery of group work and the attendance and presentation of the memory of the practical classes. Out of a total of 10 points, it will be necessary to obtain a global grade equal to or greater than 5 points to pass the subject.

In the case of single assessment, the overall evaluation of the subject will include the grades of the final theory and problem test, as well as the delivery of group work and attendance and presentation of the report of the practical classes. Out of a total of 10 points, it will be necessary to obtain a global grade equal to or greater than 5 points to pass the subject.

Students who cannot attend an individual assessment test for justified reasons (such as illness, death of a first-degree relative or accident) and provide the corresponding official documentation to the teacher or degree coordinator,will be entitled to take the test in question on another date.

Bibliography

Specific titles

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Cornish-Bowden, Athel. *Fundamentals of Enzyme Kinetics / Athel Cornish-Bowden*. 4th., completely rev. and greatly enl. ed. Weinheim: Wiley-VCH, 2012. Print.

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Links

They will be updated in the Virtual Campus of the subject

Software

Some of the programs that will be used during the course are:

EXCEL. Spreadsheet software used to analyze, represent, and manage data, as well as to perform kinetic calculations and plots in the study of biochemical reactions.

GRAFIT. Non-linear regression software used to fit experimental data to mathematical models, particularly useful for analyzing enzyme kinetics.

COPASI. A program for the simulation and analysis of biochemical networks and their dynamics.

PYMOL. A molecular visualization program.

JSME and CHEMSKETCH. Two programs that allow users to draw the structures of chemical compounds.

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	441	Spanish	second semester	morning-mixed
(PLAB) Practical laboratories	441	Spanish	second semester	afternoon
(TE) Theory	44	Spanish	second semester	morning-mixed