Biocatalysis

Code: 100867
ECTS Credits: 6

2025/2026

Degree	Type	Year
Biochemistry	OB	2

Contact

Name: Martin Hugo Pereira

Email: martin.hugo@uab.cat

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 subjects (first semester) are necessary to be able to follow the subject correctly. In particular, those of the following subjects: Thermodynamics and Chemical Kinetics, Organic Chemistry of Biochemical Processes, Biochemistry I, Biochemistry II, Chemistry and Protein Engineering, Basic and Advanced Instrumental Techniques.
For some activities, a basic level of reading comprehension of English is required.

Objectives and Contextualisation

The subject Biocatatalization focuses on the study of enzymes. The knowledge of enzymes is key in the Biochemistry and related sciences given their role as catalysts of biological reactions and applications in biotechnological processes. The subject analyzes enzymes from different perspectives: 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 the biotechnological and biomedical applications.
Specific objectives of the subject:
Knowledge of the general characteristics, classification and testing methods of enzymatic activity.
Analysis of enzymatic kinetics and determination and meaning of kinetic parameters.
Knowledge of enzymatic 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.

Learning Outcomes

1. CM25 (Competence) Understand metabolic pathways, catalytic and regulatory mechanisms, and energy-gathering processes involved in meeting physiological demands.
2. KM28 (Knowledge) Describe the mechanisms for obtaining energy, cellular work and enzymatic catalysis.
3. SM28 (Skill) Apply bioinformatics resources when searching databases on enzymes, metabolic pathways and pathological alterations, and to calculate enzyme kinetic parameters.
4. SM30 (Skill) Critically analyse measurable experimental parameters in tissues in normal or pathological physiological conditions and in the quantification of metabolic control.

Content

Theoretical content.

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) of students trained at the beginning of the course. The works must be submitted before a specific date through the Virtual Campus tool.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem solving classes and the use of computer applications	10	0.4	CM25, KM28, SM28, SM30, CM25
Theory classes	35	1.4	CM25, KM28, SM30, CM25
Type: Supervised			
Group tutorial	2	0.08	CM25, KM28, SM28, SM30, CM25
Type: Autonomous			
Analysis and problem solving	20	0.8	CM25, KM28, SM28, SM30, CM25
Study	57	2.28	CM25, KM28, CM25
Teamwork resolution of problems and delivery through the Campus Virtual Platform	19	0.76	SM28, SM30, SM28

The subject of Biocatalysis consists of theoretical classes, problem solving classes and use of computer applications, resolution and delivery of group questions and tutorials. The training activities of the subject are complemented by the practical contents of training in the field of enzymes taught in the course Integrated Laboratory 4. The following describes the organization and teaching methodology that will be followed in these types of training activities.

Theory classes:

The content of the theory program will be taught mainly by the teacher in the form of master classes with audiovisual support. The presentations used in class by the teacher will be available in the Virtual Campus of the subject before the start of each of the topics of the course. These expository sessions will be the most important part of the theory section. It is recommended to have the material published in the Virtual Campus to be able to follow the classes more comfortably. In order to consolidate and clarify the contents explained in class, it is advisable to consult regularly the books recommended in the Bibliography section and the links and resources indicated in the different topics, which contain information related to the processes explained in

class.

Classes of problem solving and use of computer applications:

In these sessions the class group will be divided into two groups (A and B). The students should check the group to which they belong and attend the corresponding classes. There will be 10 problem sessions that will be devoted to solving problems related to the contents of the theory program and the use of computer applications related to enzymes.

It is intended that these classes serve to consolidate the contents previously worked in the theory classes and also to know some of the experimental strategies, the interpretation of scientific data and the resolution of problems based on real experimental situations.

Resolution and delivery of teamwork:

This activity aims to work on the competence of teamwork, through the organization of students in working groups in which all members must actively participate in the resolution of problems.

The methodology of this activity will be the following:

At the beginning of the course the students will be organized in groups of four people, registering the groups through the Virtual Campus before the deadline indicated by the teacher.
The groups will work the problems indicated for this activity outside of class time.
The works will be delivered through the Virtual Campus. The qualification obtained will be applicable to all the members of the working group to which the student belongs.

The delivery statements will be published through the Virtual Campus where the delivery dates will also be indicated.

Tutorials

Individual tutorials will be carried out at the request of the students. In the event that the number of applications was extremely high, especially in the face of partial examinations, a classroom tutorial could be held before each partial of theory (two in total), that would be announced through the Virtual Campus in due time. The objective of these sessions will be to solve doubts, review basic concepts and guide on the sources of information to consult. These sessions will neither be used to expose new topics nor to advance in the theory program but they will be sessions of debate and discussion.

Material available in the Virtual Campus of the subject:

Presentations used by the teacher in theory classes.

Statements of the problems or cases to work to the classes of problems. It will include the problems of group work.

Programming and information on teaching activities (classroom classes, tutorials, evaluations, ...).

Questions towork in group teams.

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.	70%	4	0.16	CM25, KM28, SM30
Evaluation of homework sent by the Virtual Campus	10%	0	0	CM25, SM28, SM30
Resolution of problems and practical cases and use of computer applications	20%	3	0.12	SM28, SM30

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

Continuous assessment.

The objective of 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.

Theory (70% of the overall grade)

Individual evaluation through:

Two partial tests with multiple-choice questions and short questions, which will be eliminatory if their qualification is equal to or greater than 4 (out of 10). The weight of each test will be 35% of the overall grade.

A test of recovery of theory partials with multiple-choice questions and short questions corresponding to the first and/or second partials. To participate in the recovery, students must have been previously evaluated in a set of activities whose weight equals to a minimum of two thirds of the total grade of the subject or module. Therefore, students will obtain the "non-Valuable" qualification when the evaluation activities carried out have a weighting of less than 67% in the final grade.

Students who have obtained a grade lower than 4.0 (out of 10) in the first and/or partial will have to take the recovery exam of the corresponding partial (s) (first partial, second partial or both).

The total weight of the theory evaluation will be 70% of the overall grade.

Problems (20% of the overall grade)

1-Individual evaluation:

Two partial tests with problems, which will be eliminatory if their qualification is equal to or greater than 4 (out of 10). The weight of each test will be 10% of the overall grade.

A test of recovery of partial problems with problems corresponding to the first and/or second partials. Students who have obtained a grade lower than 4.0 (out of 10) in the previous first and/or second partial will have to take the recovery exam of the corresponding partial (s) (first partial, second partial or both).

The weight of the individual evaluation of problems will be 20% of the overall grade.

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

Assignments through the Virtual Campus: (10% of the overall grade)

Periodically (2 times during the course), two works will be proposed that must be solved before a specific date. The works prepared in groups of 3 or 4 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 considered. 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 the work, the qualification obtained by the group will not be applied or may be reduced. The weight of each delivery will be 5% of the overall grade.

The total weight of the evaluation through the assignments by the Virtual Campus will be 10% of the overall grade.

Examination-based assessment.

Theory (70% of the overall grade)

Individual evaluation through:

A final test, which will be carried out simultaneously with the second partial exam of the subject, in which the questions will be of the whole matter of the subject. In this test there will be multiple choice questions and short questions. The weight of this test will be 70% of the overall grade.

Problems (20% of the overall grade).

A final test, which will be carried out simultaneously with the second partial exam of the subject, in which problems of all the matter of the subject must be solved. The weight of this test will be 20% of the overall grade.

Assignments through the Virtual Campus: (10% 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 considered.

Theory and/or problems recovery test.

Students who have obtained a grade lower than 4.0 (out of 10) in the single assessment test, in the theory and / or problems part, will have to take the corresponding recovery exam: theory and / or problems.

Global evaluation of the subject.

In case of continuous evaluation, the global evaluation of the subject will include the qualifications of the two partial tests of both theory and problems, as well as the delivery of group work. 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 evaluation, the overall evaluation of the subject will include the qualification of the final test of theory and problems, as well as the delivery of group work. 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 totake the test in question on another date.

Bibliography

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

https://bibcercador.uab.cat/permalink/34CSUC_UAB/avjcib/alma991002999829706709

Grunwald, Peter. *Biocatalysis: Biochemical Fundamentals and Applications / Peter Grunwald, University of Hamburg, Germany*. Second edition. New Jersey: World Scientific, 2018. Print.

https://bibcercador.uab.cat/permalink/34CSUC_UAB/avjcib/alma991008535899706709

Bagshaw, Clive R. *Biomolecular Kinetics: A Step-by-Step Guide / Clive R. Bagshaw*. First edition. Boca Raton, FL: CRC Press, 2017. Print.

https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991000619019706709

Copeland, Robert A. *Evaluation of Enzyme Inhibitors in Drug Discovery: A Guide for Medicinal Chemists and Pharmacologists, Second Edition*. 2nd ed. Hoboken, New Jersey: John Wiley & Sons Inc, 2013. Web.

https://bibcercador.uab.cat/permalink/34CSUC_UAB/1c3utr0/cdi_igpublishing_primary_WILEYB0016830

Links

They will be updated in the Virtual Campus of the subject

Biochemistry
Berg, Jeremy ; Gregory, Gatto, Jr ; Justin, Hines ; John, Tymoczko ; Lubert, Stryer

2023 / 10

Software

Software

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

EXCEL.

Spreadsheet software to analyze, organize, and visualize numerical data.

GRAFIT.

Curve-fitting software for analyzing and plotting scientific data.

COPASI.

COPASI is a program for the simulation and analysis of biochemical and dynamic networks.

http://copasi.org/

PYMOL.

It is a molecular visualization program.

https://pymol.org

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	321	Spanish	second semester	afternoon
(PAUL) Classroom practices	322	Spanish	second semester	afternoon
(TE) Theory	32	Spanish	second semester	afternoon