FACULTAD DE CIENCIAS

GRADO DE CIENCIAS AMBIENTALES

2024/25 YEAR

BIOTECNOLOGÍA AMBIENTAL

Course details

Course name: BIOTECNOLOGÍA AMBIENTAL
Code: 101556
Degree/Master: GRADO DE CIENCIAS AMBIENTALES **Year:** 4
Field:
Character: OPTATIVA **Duration:** SECOND TERM
ECTS Credits: 6.0 **Classroom hours:** 60
Face-to-face classroom percentage: 40.0% **Study hours:** 90
Online platform: https://moodle.uco.es/

Coordinating teacher

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Brief description of the contents

1. Theory contents:

Therory will be delivered by Prof. María Dolores Roldán Ruiz.

Chapter 1. General introduction. Water and weak interactions. Structure and function of glucids.

Chapter 2. Amino acids and protein scaffolding.

Chapter 3. Enzymes: kinetics, inhibition and regulation of activity.

Chapter 4. Nucleotides and nucleic acids: structure, function and metabolism.

Chapter 5. Introduction to Environmental Microbiology. Chemical and biological pollution. Treatments of residues
and prevention of contamination.

Chapter 6. The carbon cycle.

Chapter 7. The nitrogen and sulfur cycles. Environmental hazards related to biogeochemical cycles.

Chapter 8. Bioremediation with microorganisms.

Chapter 9. Biodegradation of natural compounds.

Chapter 10. Biodegradation of xenobiotic compounds.

2. Practical contents:

The practical classes will be delivered by Prof. Lara Sáez Melero in the classroom or in the laboratory.

2.1 In the classroom, case studies will be solved related to:

2.1.1 pH and physic-chemical properties of proteins.

2.1.2 Enzymology.

2.1.3 Informatic analyses of biological components (proteins/genes).

2.2. In the laboratory, designed experiments will be based on:

2.2.1. Assimilation of cyanide by heterotrophic bacteria. Media culture preparation and physiological characterization of bacteria grownin the presence of hazardous pollutants.
2.2.2. PCR (polymerase chain reaction) of genes present in mutant or wild-type strains.

Prerequisites

Prerequisites established in the study plan

Students can register in this subject only if they have completed previously 60 credits (on basic formation) plus at least 60 credits (on compulsory subjects). The knowledge of English language (B1 level) is compulsory.

Recommendations

The knowledge of English language (B2 or higher level) is highly recommended.

Study programme

1. Theory contents

Unit 1. Water and weak interactions. Structure and function of carbohydrates.
Contents: Structure and physical-chemical properties of water. Acids and bases. Buffer solutions. Nature of non-covalent interactions. Interactions between macromolecules in solution. Classification and main functions of carbohydrates. Monosaccharides: chemical characteristics, isomers and conformational analysis. Glycosidic bond. Main disaccharides. Polysaccharides of energy storage. Structural polysaccharides. Glycosaminoglycans. Glycoconjugates.
Unit 2. Amino acids and protein structure.
Contents: Types of amino acids. Peptide bond. Natural peptides. Structural levels of proteins and interactions. Protein folding: chaperones and other auxiliary elements of folding. Evolution of proteins.
Unit 3. Enzymes: kinetics, inhibition and regulation of enzymatic activity.
Contents: Characteristics of enzymes as catalysts. Nomenclature and classification. Concept of active site concept. Enzyme-substrate interaction. Essential functional groups in catalysis. Factors that contribute to catalytic efficiency. Michaelis-Menten equation. Concept and meaning of kinetic parameters. Types of inhibition. Control of enzymatic activity. Regulatory enzymes. Allosterism and cooperativity. Interconvertible enzymes. Activation by proteolytic cleavage. Control of the amount of enzyme: synthesis and degradation. Technology of enzymes.
Unit 4. Nucleotides and nucleic acids: structure, function and metabolism.
Contents: Nucleosides and nucleotides. Structure and conformations of DNA. Physico-chemical properties of DNA. DNA packaging. DNA replication. Mutations in DNA and mutational repair mechanisms. RNA structure. RNA synthesis. RNA polymerases and transcription factors. RNA processing and maturation. Translation of messenger RNA. DNA-protein interactions and basic principles of transcription and translation regulation. Basic techniques of molecular biology. Genomics and proteomics. Metagenomics.
Unit 5. Introduction to Environmental Biotechnology. Chemical and biological contamination. Waste treatment and ways to avoid contamination.
Contents: Importance of biotechnology in the current society. Interest in environmental biotechnology and application of biotechnology to different environmental problems. General concepts. Causes and

types of pollution. Natural compounds and xenobiotic compounds. Hormonal disruptors. Biodegradation. Biocorrosion and biodeterioration. Biotransformation. Emission and transport of pollutants. Treatment of toxic wastes. Biological pest control. Competition, antibiosis and exploitation.

Unit 6. Carbon cycle.

Contents: Carbon compounds in the biosphere. Glycolysis. Fermentative destinations of pyruvate. Entry of other sugars into the glycolytic pathway. Gluconeogenesis. Glycogen biosynthesis and degradation. Pentose phosphate pathway. Central role of the Krebs cycle in intermediate metabolism. Glyoxylate cycle. Organization and operation of the electronic transport chain. Structure and mechanism of action of ATP synthase. Inhibitors and uncouplers of the electron transport chain. Photosynthetic fixation of carbon dioxide: Calvin-Benson cycle. Methylotrophy and methanotrophy. Methanogenesis.

Unit 7. Nitrogen and sulfur cycles. Environmental problems associated with biogeochemical cycles.

Contents: Nitrogen in the biosphere. Molecular nitrogen fixation. Nitrate assimilation. Ammonium assimilation. Ammonification. Nitrification. Denitrification and disimilatory reduction of nitrate. Anaerobic ammonium oxidation (Anamox). Sulfur in the biosphere. Sulfate assimilation. Respiratory sulfate reduction (desulfurication). Non-assimilative reduction of sulfur compounds. Oxidation of sulfur compounds (sulfurication). Cycles of iron, phosphorus and other elements. Biomining. Acid rain. Pollution by nitrogen fertilizers. Eutrophication. Global warming and greenhouse effect.

Unit 8. Biodegradation carried out by microorganisms.

Contents: General concepts. Organisms used for biodegradation. Biodegradation and bioremediation in situ and ex situ. Biomagnification (inoculation of microorganisms). Biostimulation (addition of nutrients). Consortia of microorganisms and syntrophy. Physical and environmental factors that affect biodegradation. Design of bioreactors for ex situ biodegradation.

Unit 9. Biodegradation of natural compounds.

Contents: Biodegradation of cellulose and lignin. Biodegradation of cyanide and derivatives. Biodegradation of plastics (biodegradable polymers). Biodegradation of petroleum and its derivatives. Biodegradation of alpechines and waste from oil production. Biodegradation of natural aromatic compounds: Cleavage in the *ortho* or pathway of the 3-oxoadipate and cleavage in the *meta* or pathway of the TOL plasmid. Biotechnology of catabolic plasmids. Genetically engineered organisms (GMO) and biocontainment mechanisms: Genetic containment and biological containment.

Unit 10. Biodegradation of xenobiotic compounds.

Contents: Biodegradation of chloroaromatic compounds. Biodegradation of dioxins and chlorinated dibenzofurans. Biodegradation of polychlorinated biphenyls (PCBs). Biodegradation of pentachlorophenol. Biodegradation of nitroaromatic compounds. Aerobic oxidative pathways: monooxygenases and dioxygenases. Reductive aerobic pathways: nitroreductases and hydride transferases. Anaerobic pathways: cometabolism of 2,4-dinitrophenol in *Rhodobacter*. Biodegradation of 2,4,6-trinitrotoluene (TNT). Biotechnologies associated with nitroaromatic compounds. Bioremediation of nitroaromatics. Antibacterial and antitumor therapeutic biotechnologies.

2. Practical contents

Part of the practical content will consist of solving and discussing practical exercises and complementary questions to the theoretical content. This is an in-person activity with practical classroom content. Another part of the practical content will consist of carrying out Laboratory Practices. Tutorials will also be carried out to resolve doubts and discuss aspects related to the subject. Finally, group presentations will be made in poster form as a complementary face-to-face

activity, which will deal with applications and aspects related to the contents of the theoretical program that have not been treated in detail. This activity will be evaluated by both the teacher and the students in the group.
The contents of the Classroom Practices will be:
1. pH and physical-chemistry of proteins
2. Enzymology
3. Computer analysis of biological samplesRegarding Laboratory Practices, a total of 2 practices will be carried out, the content of which may vary depending on the number of students and the availability of material and laboratories. The possible practices will be the following:
Practice 1. Regulation of cyanide degradation in *Pseudomonas pseudoalcaligenes*.
Practice 2. Detection by PCR of mutant strains of *Pseudomonas pseudoalcaligenes* affected in the cyanide degradation process.
The contents of the Tutorials and posters will depend on the interests of the students and the development of the subject, so they will be established throughout the course. In any case, they will deal with aspects related to theoretical or practical content, including biochemical methodologies, possible technological applications, etc.

Bibliography

1. Bibliografía básica:
1. Nelson DL y Cox MM. Lehninger Principles of Biochemistry, seventh Edition. Omega, 2018.
2. Nelson DL y Cox MM. Lehninger. Principios de Bioquímica, 7ª Ed. Omega, 2018.
3. Ramesh KV. Environmental Microbiology. MJP Publisher, 2019.
4. Barton L, McLean RJC. Environmental Microbiology and Microbial Ecology, 2019.
5. Dash S y Dash H.Elsevier. Microbial Biodegradation and Bioremediation: Techniques and case studies for environmental pollution, Elsevier, 2021.

2. Bibliografía complementaria:
1. McKee T y McKee JR. Bioquímica. La Base Molecular de la Vida, 6ª Ed. McGraw-Hill-Interamericana, 2014.
2. Atlas RM y Bartha R, Ecología Microbiana y Microbiología Ambiental, 4ª ed., Addison-Wesley, 2002.
3. Nelson DL y Cox MM. Lehninger. Principios de Bioquímica, 6ª Ed. Omega, 2014.
4. Chandra R. Advances in Biodegradation and bioremediation of industrial waste. CRC Press, 2015.
5. Wild JR, Varfolomeyev SD, Scozzafava A. Perspectives in Bioremediation: Technologies for Environmental Improvement. Springer, 2013.

Methodology

Methodological adaptations for part-time students and students with disabilities and special educational needs

Individual adjustements will be made for part time or disabled students.

In the case of students with special educational needs, profesors will meet with these students to establish the most appropriate adaptations for each particular case, following the indications of the report issued by the Inclusive Education Unit (Unidad de Educación Inclusiva).

Face-to-face activities

Activity	Large group	Medium group	Total
Information processing activities	-	16	16
Oral communication activities	1	-	1
Practical experimentation activities	1	9	10
Projects based on the course contents	26	-	26
Tutorial action activities	2	-	2
Written expression activities	3	2	5
Total hours:	***33***	***27***	***60***

Off-site activities

Activity	Total
Exercise and problem solving activities	30
Information processing activities	45
Information search activities	15
Total hours	***90***

Results of the training and learning process

Knowledge, competencies and skills

C01 Identifies the different variables that influence the environment

COM04 Interpret data qualitatively and/or quantitatively

COM05 Integrate experimental evidence found in field studies and/or laboratories with theoretical knowledge

COM07 Work as a team, valuing the ability to lead and organize work teams

COM08 Show sensitivity towards environmental issues

Assessment methods and instruments

Intended learning outcomes	Examination	Group or individual globalizing projects	Means of practical execution	Students assignments
C01	X	X		
COM04	X		X	
COM05			X	X
COM07		X		X
COM08				X
Total (100%)	***30%***	***20%***	***40%***	***10%***
Minimum grade (*)	***5***	***5***	***5***	***5***

(*)Minimum mark (out of 10) needed for the assessment tool to be weighted in the course final mark. In any case, final mark must be 5,0 or higher to pass the course.

General clarifications on instruments for evaluation:

To succeed students will have to obtain a final score of 5 out of 10.

All activities contemplated in the evaluation instruments, except the exam, will be part of the continuous evaluation. The exam will have a maximum value of 30% of the final grade, the classroom and laboratory portfolio activities (student assignments) will account for a maximun of 10% of the final grade, the means of practical execution, including classroom practices (accounting for 25% of the final grade) and laboratory practices (contributing up to 15% of the final grade), and group/individual globalizing projects will account for a maximum value of 20% of the final grade.

The calification obtained in each tool or instrument of evaluation will be kept, if they are succeded, for all deadlines of the same academic year.

Calification of practical activities in the laboratory will be kept for students who have undertaken this subject for more than one academic year.

Clarifications on the methodology for part-time students and students with disabilities and special educational needs:

Specific learning conditions will be provided for part-time students or disabled students.

Clarifications on the evaluation of the extraordinary call and extra-ordinary call for completion studies:

The same criteria used for ordinary deadlines.

Qualifying criteria for obtaining honors:

As previously stated by UCO (article 80 of the UCO Regulation).

Sustainable development goals

Good health and well-being
Quality education
Gender equality
Clean water and sanitation
Affordable and clean energy
Industry, innovation and infrastructure
Sustainable cities and communities
Responsible consumption and production
Climate action

Other Faculty

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The methodological strategies and the evaluation system contemplated in this Teaching Guide will respond to the principles of equality and non-discrimination and must be adapted according to the needs presented by students with disabilities and special educational needs in the cases that are required. Students must be informed of the risks and measures that affect them, especially those that may have serious or very serious consequences (article 6 of the Safety, Health and Welfare Policy; BOUCO 23-02-23).