COURSE DATA

Data Subject	
Code	33171
Name	Biochemistry
Cycle	Grade
ECTS Credits	9.0
Academic year	2024 - 2025

Study (s)

Degree	Center	Acad. year	Period
1102 - Degree in Biotechnology	Faculty of Biological Sciences	2	Annual

Subject-matter

Degree	Subject-matter	Character
1102 - Degree in Biotechnology	82 - Biochemistry	Obligatory

Coordination

Name	Department
GARCIA FERRIS, CARLOS	30 - Biochemistry and Molecular Biology
GONZALEZ BOSCH, CARMEN	30 - Biochemistry and Molecular Biology

SUMMARY

The subject "Biochemistry" is part of the module "Biochemistry, Cell Biology and Molecular Biology". It is mandatory, and is taught in the second year of the Degree in Biotechnology. It consists of 9 ECTS credits, which are held throughout the course by a theoretical-experimental approach, which is achieved by complementing the knowledge with other of practical nature, such as problem solving and performing work laboratory, where students apply some of the concepts previously studied.

The aim of the course "Biochemistry" is to provide students with basic knowledge about the structure of the main biological macromolecules, analyzing the forces that stabilize and allow interactions with other molecules, the mechanisms of enzyme-catalyzed reactions, their kinetics and regulation, and the molecular mechanisms by which cells obtain, store and transform energy.

The course is organized in a total of four blocks whose contents are summarized below:

I. PROTEIN STRUCTURE (Lessons 1 to 6). Chemical composition and characteristics of living matter. Weak interactions between macromolecules. Amino acids. The peptide bond. Structural protein levels. Globular proteins, fibrous proteins. Transmembrane proteins. Conformational stability of proteins.

II. THE STRUCTURE OF NUCLEIC ACIDS (Lessons 6 to 10). Nucleotides. The phosphodiester bond. Structural levels in the DNA. Packaging of DNA in eukaryotes. RNA structure. Interactions between molecules. Macromolecular complexes.

III. ENZYMOLOGY (Lessons 11 to 16). General characteristics of enzymes and enzymatic catalysis. Enzymatic cofactors. Kinetics of enzymatic reactions: Michaelis-Menten equation. Enzyme inhibition. Molecular mechanisms of enzyme regulation. Biotechnological applications of enzymes.

IV. BIOENERGETICS (Lessons 17 to 23). Quantitative Bioenergetics. Biochemistry of ATP. Coupled reactions. Energy sources and strategies for the generation of ATP. Structure and properties of biological membranes. Thermodynamics and kinetics of transport through membrane. Chemiosmotic theory. ATP synthases. Respiratory chains. Oxidative phosphorylation. Photoelectronic transport chains. Photophosphorylation.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

It is advisable to follow this course after having successfully passed all other subjects components of matter Chemistry (Chemistry and Biomolecular Chemistry), as well as those more basics.

COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

1102 - Degree in Biotechnology

- Be able to identify the molecules that make up a living being.
- Be able to determine metabolite concentrations, kinetic and thermodynamic parameters and control coefficients of intermediate metabolism reactions.
- Be able to analyse the energy cost of the cellular processes.

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

GENERAL OBJECTIVES

• Understand the structure and properties of biological macromolecules, and its relation to the role played by them.

• Understand the functioning of enzymes and their regulation.

• To know and apply the chemiosmotic theory as the central dogma of universal energy transduction processes in living beings, and understand the importance of biological membranes in these processes, and understanding the mechanisms of production and energy transformation in living organisms.

METHODOLOGICAL OBJECTIVES

• Gain experience in laboratory work in adequate conditions of safety.

• Apply the scientific method to the experimental work.

• Become familiar with the sources of information, through both traditional and new technologies.

• Enhance the skills to work as a team.

SKILLS TO ACQUIRE

• Strength in basic biochemical knowledge.

• Ability to solve quantitative problems and issues through the integrated application of knowledge learned.

• Familiarization with the experimental work and the basic techniques of biochemistry laboratory.

• Ability to perform basic laboratory protocols and interpret experimental data.

• Ability to obtain and develop logical conclusions and reasonable assumptions.

• Ability to analyze and understand scientific texts.

• Use proper language of biochemistry.

• Understanding the chemiosmotic theory, its assumptions and predictions and their experimental validation.

• Application of knowledge of the three dimensional structure of proteins to study vectorial function of energy-transducing molecular machines.

SOCIAL SKILLS

• Ability to argue from rational criteria in the context of a scientific discussion.

• Ability to work in teams and in multidisciplinary contexts.

• Ability to find the right information in order to address the scientific problems that are asked, sort and analyze it critically.

• Ability to build a comprehensive text written and organized.

• Ability to prepare, public presentation and defense of a job.

• Ability to disseminate scientific knowledge.

• Autonomous learning and adapting to new situations.

• Knowledge and application of scientific method.

DESCRIPTION OF CONTENTS

1. LESSON 1.- Introduction

Biochemistry: relationship to other Sciences. Biological polymers and macromolecular complexes. Weak interactions between macromolecules: electrostatic, hydrophobic, hydrogen bonding and van der Waals forces.

2. LESSON 2.- Primary and secondary structure of proteins

Structure and classification of amino acids hydrophobicity scale. Peptide bond: peptides and proteins. Properties of the peptide bond. Conformational constraints of the peptides. Ramachandran plot. Secondary structure: alpha helix, beta sheet and turns. Secondary structure prediction.

3. LESSON 3.- Upper structure of proteins

Fibrous proteins: alpha keratin, collagen and fibroin. Globular proteins. Tertiary and quaternary structure of proteins. Supersecondary structures: motifs. Structural domains. Structural classification of proteins.

4. LESSON 4.- Conformational stability of proteins

Native and denatured state. Hydrophobic core and solvent-exposed surface. In vitro protein folding. Protein folding in vivo. Molecular chaperones.

5. LESSON 5.- Dynamics of proteins

Functional classification of proteins. Ligand binding. Cooperativity and allosterism. Study of myoglobin and hemoglobin.

6. LESSON 6.- Secondary structure of DNA

Nitrogenous bases, nucleosides and nucleotides. Properties. The phosphodiester bond. Determination of DNA secondary structure. Watson and Crick model of double helix. Detailed conformation of DNA and the sequence dependence. DNA structural variability. Other types of double helix: DNA A, DNA Z and DNA H. DNA curved. Triple helices. Denaturation and renaturation of the DNA.

7. LESSON 7.- DNA topology

Supercoiling. Parameters of interest: index of bond and torsion. Relationship between the degree of supercoiling and the different conformations of DNA. Biological functions of supercoiling. DNA topoisomerases type I and II. Upper structure of DNA in prokaryotes. Organization of the bacterial chromosome.

8. LESSON 8.- Packaging of DNA in eukaryotes

Histones. Nucleosomal structure of chromatin. DNA conformation models on the octamer of histones. Post-translational modifications of histones and epigenetic mechanisms. Higher levels of chromatin fiber organization: the solenoid, the bonds and the metaphase chromosome.

9. LESSON 9.- Structure of RNAs

Differential characteristics with the structure of DNA. Main types of RNA: structure. Three-dimensional structure of tRNA. Codon-anticodon pairing. Other natural RNA: small RNAs. MicroRNAs. Ribozymes.

10. LESSON 10.- Macromolecular complexes

General characteristics of supramolecular complexes. Ribonucleoproteins: the ribosome.

11. LESSON 11.- Overview of enzymes

Types of enzymes. The enzyme-substrate complex: the active site. Involvement of cofactors in enzyme activity. Classification and nomenclature of enzymes.

12. LESSON 12.- Enzymatic catalysis

Enzyme-substrate interaction. Energy profile of an enzymatic reaction: transition state and reaction intermediates. Effects of orientation and proximity. Mechanisms of enzymatic catalysis. Examples.

13. LESSON 13.- Kinetics of monosubstrate reactions

The Michaelis-Menten equation. Meaning of the kinetic parameters: Km, Vmax and kcat: efficiency and specificity. Determination of kinetic parameters. Effect of pH and temperature on reaction rate. Experimental methods for measuring enzyme activity.

14. LESSON 14.- Enzyme Inhibition

Types of inhibition. Reversible inhibition. Graphic representations. Significance of inhibition constants. Irreversible inhibitors. Applications of enzyme inhibition.

15. LESSON 15.- Molecular mechanisms of enzymatic regulation

Regulation of enzyme activity. Covalent modification of enzymes: zymogens and interconvertible enzymes. Amplification of signals. Regulation by reversible binding of ligands: allosterism.

16. LESSON 16.- Biotechnological applications of enzymes

Use of enzymes in the diagnosis of diseases. Industrial applications. Development of new biocatalysts.

17. LESSON 17.- Introduction to Bioenergetics

What does Bioenergetics study? Energy flows in living beings. Quantitative Bioenergetics: quantification of the driving forces. Thermodynamics of life. Gibbs free energy and spontaneity of a chemical reaction. Thermodynamics of redox reactions: redox potential and Nernst equation. Thermodynamics of transport across membrane: electrochemical potential. Membrane potential.

18. LESSON 18.- ATP

Role of ATP in energy metabolism. Biochemistry of ATP. Phosphoryl, adenylyl and pyro phosphoryl group transfer. Chemical work: coupling between endergonic and exergonic reactions. Energy sources and strategies for the generation of ATP: substrate-level phosphorylation and electrophosphorylation.

19. LESSON 19.- Transport through membrane

General characteristics of biological membranes. Classification of types of transport. Kinetic and thermodynamic considerations. Simple diffusion. Passive transport. Ion channels. Aquaporins. K + channel and acetylcholine channel. Role of ion channels in sensory processes. Passive glucose transporters. Ionophores. Active transport. Ion pumps: Na+/K+-ATPase and Ca2+-ATPase. Cotransporters.

20. LESSON 20.- Chemiosmotic theory

Background and postulates of Mitchell. Chemiosmotic theory. The circuit of protons. Quantification of the proton motive force. Energy-transducing membranes. Generators and consumers of the proton motive force. El mon del sodi.

21. LESSON 21.- ATP synthases

Types of ATP synthase. Structure and composition of the ATP synthase type F. Rotational mechanism of catalysis. Role of proton motive force: transduction of osmotic energy to chemical energy. Operating mechanism of the a/c interface. Regulation. ATP synthase coupled to Na+ gradients. The archaeal-type ATP synthases.

22. LESSON 22.- Proton motive force generators (1): respiratory chains

Electron carriers of the respiratory chain. Mechanism of electron transport: tunneling. Organization and functioning of the mitochondrial electron transport chain. Generation of proton motive force: redox loops and proton pumps. Oxidative phosphorylation. Balances. Respiratory control. Inhibitors and uncouplers. Natural uncouplers. Other respiratory chain. Sodium motive force generators.

23. LESSON 23.- Proton motive force generators (2): photosynthetic chains

Photosynthetic pigments. Light absorption and mechanisms of energy dissipation. Molecular mechanism of bacterial reaction center. Bacterial photosynthetic chains: organization and operation of the electron carriers. Complex light collectors. Photosynthetic chains based on two photosystems: organization and operation of the electron carriers. Proton motive force generation and ATP synthesis coupled (photophosphorylation). Cyclical operation. Balances. Other mechanisms that generate proton motive force driven by the light: bacteriorhodopsin.

24. Practice: Problems

SESSION 1. Buffer solutions
SESSION 2. Enzyme kinetics
SESSION 3. Bioenergetics

25. Practice: Laboratory

SESSION 1. Protein analysis: Titration of thiol groups. Study in native and denaturing conditions; separation of proteins: ion exchange chromatography.
SESSION 2. Isolation and analysis of chromosomal and plasmid DNA. Determining the size, number and shape of DNA by agarose gel electrophoresis.
SESSION 3. Enzyme activity assay of alcohol dehydrogenase. Determination of kinetic parameters.
SESSION 4. Determination of residues essential for enzymatic activity of aldolase.
SESSION 5. Transport through membrane: dissipation of the proton gradient by ionophores in artificial

vesicles using an ionophore.
SESSION 6. Study of mitochondrial respiratory chain of rat liver by the use of an oximeter: substrates, inhibitors and respiratory control.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	61,00	100
Laboratory practices	18,00	100
Classroom practices	9,00	100
Tutorials	2,00	100
Study and independent work	60,00	0
Preparing lectures	45,00	0
Preparation of practical classes and problem	30,00	0
TOTAL	225,00	

TEACHING METHODOLOGY

The development of the subject is divided into:

Theory classes. In these classes the teacher will present the relevant contents of the subject, in order to provide an overview of the matter. It will be used the media necessary for agile development and consistent of them. The teacher will make accessible when required, on the virtual platform to support classroom teaching (Aula virtual), the material needed to properly follow the lectures, and will indicate the most recommended resources for further preparation of the topic in greater depth.

Questions classes. These sessions will be interspersed with the lectures, usually at the end of each of the sections. These classes will reinforce the concepts presented in the theoretical sessions and stimulate the active participation of students through the resolution of issues. The teacher will prepare a series of questions for each topic or subject block that will work individually (by preparing their staff) and collectively (through exposure and discussion of them in group class) various aspects with the theoretical contents. This activity will reveal how students assimilate concepts, and better evaluate student work. For discussion of the issues students will be notified in advance of the date of such activity and the issues to be brought ready for discussion.

Practical classes of problems. There will be 9 sessions of one hour throughout the course, six in the first quarter and three in the second. A list of problems with the result will be provided prior to the classes of each part. The teacher will leave in Aula Virtual a series of theoretical notions about the resolution of each type of problems, and examples of sample problems solved. During the classes will be solved the most representative problems, performing other individually in their study time.

Practical classes of laboratory. They are of compulsory attendance. There will be six sessions of 3 hours, four in the first quarter and two in the second. Students will have a booklet in advance of the sessions, with a short introduction of the theoretical concepts and a detailed protocol, which should bring prepared before each session. During the course the students will have a questionnaire on the content of each session.

Small group tutorials. There will be two group tutoring sessions throughout the course, one at the end of each semester. These sessions will discuss a scientific reading or current issues related to the subject, or may be used to answer questions, and for monitoring and continuous assessment of students. Attendance at this activity will be compulsory and evaluated.

Individual tutorials. To resolve specific issues: may be personal, online or by e-mail.

EXPLANATION: Attendance at the lectures, questions and problems is not required, but is measurable.

EVALUATION

Assessment of learning knowledge and skills achieved by students will be continuously along the course. It will combine an evaluation result from direct contact with students during classes and tutoring issues, with the activities in class, work conducted by the students and exams.

ATTENTION: To pass the course will be necessary to obtain an overall score of 5 out of 10, having obtained at least 50% of the grade of theory and questions, problems and laboratory practice.

Evaluation of the theoretical contents (theory and questions)

The result of this evaluation will score 7.0 points from the subjet grade (70 % of the final score). To pass the course will be necessary to have passed the theory (higher or equal to 5 points out of 10).

The percentage representing each part will be: 22% block I, 21% block II, a 24% block III, and 33% block IV.

There will be a mid-term exam qualifying after the first quarter (corresponding to the blocks I, II and III), and a final exam, corresponding to the first call, which will include a second mid-term exam (corresponding to block IV), as well as a retake of the pending first mid-term exam. The percentage representing each part in the final grade will be: 67% the first quarter and 33% the second.

It will be considered passed and therefore eliminated the matter of a mid-term exam if the rating is equal to or greater than 5 out of 10, provided that it has been scored in all its thematic blocks above 40% of its value.

From **4.75** on 10, the matter of the first mid-term exam will be potentially weighted average, provided that it has been scored in all its thematic blocks above 40% of its value, **and from 4,50 on 10 in the second exam.**

It will be considered the theory passed by mid-term exams in the first call if the average score obtained between the two sets is 5 out of 10, h**aving scored in the first exam 4,75 or higher on 10 and in the second exam 4,50 or higher on 10**.

In the case of not passing the theory in the first call, the partial scores that are passed or potentially weighted average will be only saved until the second call.

In the event of failure to pass the theory at the first call, it will be possible to do a retake of those pending parts in the final exam of the second call, including those with a score below **4.75 on 10 in the first exam and below 4.50 on10 in the second exam**) or at least one of them when both partials are potentially weighted average.

In the case of failing the course in the first call, having passed the theory (equal or superior to 5.0 on 10) the obtained grade will be only kept until the second call.

In the second call will apply the same standards and considerations set out for the final examination at the first call.

Evaluation of the practical classes of problems

The result of this evaluation will point 1.0 of the final grade for the course (10 % of the final score). To pass the course will be necessary to have passed the practical classes of problems (grade not less than 5 points on 10).

The last session of each block of problems (two blocks in the first quarter and one in the second quarter) will be devoted to achieving a partial test, consisting of solving a problem. Each part represents 1/3 of the final grade.

One partial will be considered passed, and therefore eliminated, if the obtained score is equal or superior to 5.0 on 10.

From 4.5 on 10, the matter of a partial exam will be potentially weighted average.

Problems will be considered passed, and therefore eliminated by mid-term exams, if the average score obtained from the three tests is at least 5 out of 10 and all have scored 4,5 or higher on 10.

In case the mid-term exams have not been passed, it will be possible to do a retake of those pending parts of problems in the final exam (first or second call), including those with a score below 4,5 or at least one of those potentially weighted average when all the parts have scored 4,5 or higher but the average results below 5.

In the case of not passing the problems on the first call, the passed or potentially weighted average mid-term scores will be only saved until the second call.

In the case of failing the course in the first call, if problems are passed (overall score not less than 5 over 10) the grade will be only saved until the second call.

In the second call will apply the same standards and considerations set out for the final examination of the first call.

In the case of failing the subject, if the problems are passed the grade will be saved at the most three academic courses. Parts are not saved for next academic course.

Evaluation of laboratory practical classes

The grade of this activity represents 2.0 points of the final grade for the subject (20 % of the final score). To pass the course will need to have passed the laboratory (5 points on 10).

Laboratory practical classes are compulsory and will be evaluated by performing two tests on the content of practice sessions to be held at the end of each quarter. The percentage representing each part in the final laboratory grade will be: 67% the first quarter and 33% the second.

One partial will be considered passed, and therefore eliminated, if the obtained score is equal or superior to 5.0 on 10.

From 4.5 on 10, the matter of a mid-term exam will be potentially weighted average.

Laboratory is considered passed by parts, and therefore eliminated, if the grades average is 5 out of 10, having scored in both mid-term exams 4,5 or higher on 10.

In the case of fail the laboratory during the course it will be possible to do a retake of the pending parts in the final exam (first call or second call), including those with a score below 4,5 or at least one of them when both partials are potentially weighted average.

In the case of not passing the lab in the first call, the mid-term test scores passed or potentially weighted average will be only saved until the second call.

In the case of failing the course in the first call, if the laboratory is passed (overall rating equal to or greater than 5 on 10) the grade will be saved for the second call.

In the second call will apply the same standards and considerations set out for the final examination of the first call.

In the case of failing the subject, if the lab is passed the grade will be saved for three academic courses. Lab parts are not saved for next year.

Participation in educational activities

It will be appreciated the attitude and participation of students in the various educational activities of the course (mandatory and non-mandatory). The participation in the questions, problems and laboratory could modulate up to 5% the grade obtained only it this has been passed.

REFERENCES

Basic

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