

**COURSE DATA****DATA SUBJECT****Code:** 33171**Name:** Biochemistry**Cycle:** Undergraduate Studies**ECTS Credits:** 9**Academic year:** 2026-27**STUDY (S)**

Degree	Center	Acad. year	Period
1111 - Grado en Biotecnología	Facultat de Ciències Biològiques	2	Annual

SUBJECT-MATTER

Degree	Subject-matter	Character
1111 - Grado en Biotecnología	Biochemistry	COMPULSORY

COORDINATION

GARCIA FERRIS CARLOS

GONZALEZ BOSCH CARMEN

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 5). 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. ENZYMOLOGY (Lessons 6 to 11). 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.

III. BIOENERGETICS (Lessons 12 to 18). 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.

IV. THE STRUCTURE OF NUCLEIC ACIDS (Lessons 19 to 23). Nucleotides. The phosphodiester bond. Structural levels in the DNA. Packaging of DNA in eukaryotes. RNA structure. Interactions between molecules. Macromolecular complexes.

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 / LEARNING OUTCOMES



1102 -

Be able to analyse the energy cost of the cellular processes.

Be able to determine metabolite concentrations, kinetic and thermodynamic parameters and control coefficients of intermediate metabolism reactions.

Be able to identify the molecules that make up a living being.

1111 - Grado en Biotecnología

Actuar con autonomía en el aprendizaje, tomando decisiones fundamentadas en diferentes contextos, emitiendo juicios en base a la experimentación y el análisis y transfiriendo el conocimiento a nuevas situaciones

Analizar de forma correcta el coste energético de los procesos celulares

Apply analytical, synthetic and critical thinking skills in the application of the scientific method.

Colaborar eficazmente en equipos de trabajo, asumiendo responsabilidades y funciones de liderazgo y contribuyendo a la mejora y desarrollo colectivo

Conocer las características estructurales y funcionales de las macromoléculas

Demostrar razonamiento crítico y autocrítico en el ámbito de la titulación, considerando aspectos tales como la ética profesional, los valores morales y las implicaciones sociales de las diferentes actividades realizadas

Identify the molecules that make up a living organism.

Participate in multidisciplinary teams, engaging in teamwork and collaboration.

Propose creative and innovative solutions to complex situations or problems, typical of the area of connection, to donate responses to the various professional and social needs

Que el estudiantado demuestre su capacidad para calcular correctamente los parámetros relevantes de un proceso o un experimento mediante la representación de los datos experimentales

Que el estudiantado demuestre su capacidad para utilizar las diferentes fuentes bibliográficas y bases de datos biológicas y usar las herramientas bioinformáticas

Saber comunicarse de manera efectiva, tanto de forma oral como escrita, adaptándose a las características de la situación y de la audiencia

Use English to write reports and to interpret information from protocols, manuals and databases.

Work in laboratories, including safety procedures, waste management and accurate activity logging.



DESCRIPTION OF CONTENTS

I. PROTEIN STRUCTURE

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.

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.

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.

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.

LESSON 5.- Dynamics of proteins. Functional classification of proteins. Ligand binding. Cooperativity and allosterism. Study of myoglobin and hemoglobin.

II. ENZYMOLOGY

LESSON 6. - Overview of enzymes. Types of enzymes. The enzyme-substrate complex: the active site. Involvement of cofactors in enzyme activity. Classification and nomenclature of enzymes.

LESSON 7. - 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.

LESSON 8. Kinetics of monosubstrate reactions. The Michaelis-Menten equation. Meaning of the kinetic parameters: K_m , V_{max} and k_{cat} : efficiency and specificity. Determination of kinetic parameters. Effect of pH and temperature on reaction rate. Experimental methods for measuring enzyme activity.

LESSON 9. - Enzyme Inhibition. Types of inhibition. Reversible inhibition. Graphic representations.



Significance of inhibition constants. Irreversible inhibitors. Applications of enzyme inhibition.

LESSON 10. - 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.

LESSON 11. - Biotechnological applications of enzymes. Use of enzymes in the diagnosis of diseases. Industrial applications. Development of new biocatalysts.

III. BIOENERGETICS

LESSON 12.- 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.

LESSON 13.- Biochemistry of ATP. Role of ATP in energy metabolism. Biochemistry of ATP. Phosphoryl, adenylyl and pyrophosphoryl group transfer. Chemical work: coupling between endergonic and exergonic reactions. Energy sources and strategies for the generation of ATP: substrate-level phosphorylation and electrophosphorylation.

LESSON 14.- 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.

LESSON 15.- 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. The world of sodium.

LESSON 16.- 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 A ATP synthases.

LESSON 17.- 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.

LESSON 18.- 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 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.

IV. STRUCTURE OF NUCLEIC ACIDS

LESSON 19.- Secondary structure of DNA. Nitrogenous bases, nucleosides and nucleotides. Properties. The phosphodiester bond. Determination of the secondary structure of DNA. Watson and Crick's model of the double helix. Detailed conformation of DNA and dependence on the sequence. Structural variability of DNA. Other types of double helix: DNA A, DNA Z and DNA H. Bent DNA. Triple helices. DNA denaturation and renaturation.

LESSON 20.- Supercoiling. Parameters of interest: binding rate and torsion. Relationship between the degree of supercoiling and the different DNA conformations. Biological functions of supercoiling. DNA topoisomerases type I and II. Top structure of DNA in prokaryotes. Organization of the bacterial chromosome.

TOPIC 21.- DNA packaging in eukaryotes. Histones. Nucleosomal structure of the chromatin. Models of DNA conformation on the histone octamer. Post-translational histone modifications and epigenetic mechanisms. Higher levels of organization of the chromatin fiber: the solenoid, the loops and the metaphase chromosome.

TOPIC 22.- Structure of RNAs. Differential characteristics with the structure of DNA. Main types of RNA: structure. Three-dimensional structure of tRNA. Codon-anticodon pairings. Other natural RNAs: small RNAs. MicroRNAs. Ribozymes.

TOPIC 23.- Macromolecular complexes. General characteristics of supramolecular complexes. Ribonucleoproteins: the ribosome.

**PRACTICE: PROBLEMS**

SESSION 1. Buffer solutions.

SESSION 2. Enzyme kinetics.

SESSION 3. Bioenergetics.

PRACTICE: LABORATORY

SESSION 1. Protein analysis: Titration of thiol groups. Study in native and denaturing conditions; separation of proteins: ion exchange chromatography.

SESSION 2. Enzyme activity assay of alcohol dehydrogenase. Determination of kinetic parameters.

SESSION 3. Determination of residues essential for enzymatic activity of aldolase.

SESSION 4. Transport through membrane: dissipation of the proton gradient by ionophores in artificial vesicles using an ionophore.

SESSION 5. Study of mitochondrial respiratory chain of rat liver by the use of an oximeter: substrates, inhibitors and respiratory control.

SESSION 6. Isolation and analysis of chromosomal and plasmid DNA. Determining the size, number and shape of DNA by agarose gel electrophoresis.

WORKLOAD**PRESENCIAL ACTIVITIES**

Activity	Hours
Theory	63,00
Laboratory	18,00
Classroom practices	9,00
Total hours	90,00

**NON PRESENCIAL ACTIVITIES**

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	60,00
Preparation of lessons	75,00
Preparation for assessment activities	0,00
Resolution of case studies	0,00
Total hours	135,00

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 it 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 subject grade (70% of the final score). To pass the course it 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, 24% block II, a 33% block III, and 21% 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 of the final grade will be: 46% in the first quarter and 54% in 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, if it has been scored in all its thematic blocks above 40% of its value.

From 4.5 on 10, the matter of a mid-term exam will be potentially weighted average, if it has been scored in all its thematic blocks above 40% of its value.



The theory will be considered passed by mid-term exams in the first call if the average score obtained between the two sets is 5 out of 10, having scored in both exams 4.5 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 4.5 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 grades for the course (10 % of the final score). To pass the course it will be necessary to have passed the practical classes of problems (grade not less than 5 points out of 10).

At the end 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 there will be 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 the 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 it will be necessary to have passed the laboratory (5 points out of 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 of the final laboratory grade will be 50%

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 content of a mid-term exam will potentially weight 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 and higher on 10.

In the case of failing 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 it 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 at the most 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). Participation in the questions, problems and laboratory could modulate up to 5% the grade obtained only if this has been passed.

REFERENCES

BASIC REFERENCES

Nelson, D.L. and Cox, M.M. *Lehninger Principios de Bioquímica*. Ed. Omega, 7th ed., 2018.

Stryer, L., Berg, J.M. and Tymoczko, J.L. *Bioquímica*. Ed. Reverté, 7th ed., 2013 (6th edition available in Catalan version).

Voet, D. and Voet, J.G. *Bioquímica*. Editorial Médica Panamericana, 3rd ed., 2006.

Nicholls, D.G. and Ferguson, S.J. *Bioenergetics 4*. London Academic Press, 2013.

COMPLEMENTARY REFERENCES

Alberts, B. and collaborators. *Biología Molecular de la Célula*. Ediciones Omega, 5th ed., 2010.

Boyer, R. *Conceptos de Bioquímica*. International Thomson Editores, 2000.

Horton, H.R. and collaborators. *Bioquímica*. Pearson, 4th ed., 2008.

McKee, T. and McKee, J.M. *Bioquímica. La Base Molecular de la Vida*. MacGraw Hill Interamericana de España, 2003.

Mathews, C.K., Van Holde, K.E. and Ahern K.G. *Bioquímica*. Addison Wesley, 3rd ed., 2002.

Skulachev, V.P., Bogachev, A.V. and Kasparinsky F.O. *Principles of Bioenergetics*. Springer, 2013.

Peretó, J., Sendra, R., Pamblanco, M. and Bañó, C. *Fonaments de Bioquímica*. Servei de Publicacions de la Universitat de València, 5th ed., 2005 (translation into Spanish, 2007).

Voet, D., Voet, J.G. and Pratt, C.W. *Fundamentos de bioquímica: La Vida a Nivel Molecular*. Editorial



Médica Panamericana, 2nd ed., 2007.

Blankenship, R.E. *Molecular Mechanisms of Photosynthesis*, Wiley-Blackwell, 2nd ed., 2014.