Universitat Autònoma de Barcelona

2022/2023

Structure and Function of Biomolecules

Code: 100758
ECTS Credits: 6

Degree	Type	Year	Semester
2500250 Biology	FB	1	2

Contact

Name: Susana Navarro Cantero
Email: susanna.navarro.cantero@uab.cat

Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Other comments on languages

Most of the teaching materials used will be written in English and published in the Campus Virtual

Teachers

Nathalia Varejao Nogueira

Prerequisites

There are no official prerequisites. However, it is assumed that the student has assimilated the concepts acquired during the first term, particularly those contained in the subjects of Chemistry and Cell Biology, such as those related to chemical functional groups, chemical equilibrium, basic thermodynamics, biological membranes and cellular compartmentalization.

Objectives and Contextualisation

The course Structure and Function of Biomolecules is the first part of the subject "*Biochemistry*" in the Biology degree; it covers the structural and functional characteristics of biomolecules from a point of view which is basic and simple but also with the necessary depth required for further use, mainly related to the structure and function of enzymes and the bioenergetics concepts that will be used in the second part of the subject to be taught in the third term under the name *Biosignalling and Metabolism*. Similarly, the concepts on the structure and function of biomolecules are essential for the understanding of more specialised courses in the Biology degree.

Objectives:

- To understand, based on previously acquired chemistry knowledge, the fundamental structural characteristics of biological molecules, being able to draw conclusions about their stability, functionality and ability to replicate structures.
- To acquire the conceptual basis of bioenergetics processes as a primer to the second part of the subject Biochemistry, dedicated to metabolism.
- To understand the kinetics of enzymatic action in the context of the study of biological reactions and their metabolic relationships.

- To understand the basic methods of purification, characterization, structural analysis of biomolecules and recombinant DNA methodologies.

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.
- Isolate, identify and analyse material of biological origin.
- 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

Learning Outcomes

1. Analyse a situation and identify its points for improvement.
2. Apply statistical and computer resources to the interpretation of data.
3. Be able to analyse and synthesise.
4. Be able to organise and plan.
5. Correctly use the terminology of biochemistry and its text and reference books.
6. Critically analyse the principles, values and procedures that govern the exercise of the profession.
7. Describe the basic structural and functional characteristics of amino acids, proteins, glucids, lipids and biological membranes, nucleotides and nucleic acids.
8. Describe the catalytic mechanisms of enzyme reactions and their inhibition and regulation mechanisms.
9. Describe the structure, function and regulation of proteins involved in oxygen transport and examples of the deficiencies involved in pathologies.
10. Identify structural protein domains and motifs and their functional and evolutionary relationships.
11. Identify the most suitable experimental approaches to study the structure and function of biomolecules.
12. Propose new methods or well-founded alternative solutions.
13. 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.
14. 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.
15. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
16. Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.

17. 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.
18. Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
19. Take sex- or gender-based inequalities into consideration when operating within one's own area of knowledge.

Content

THEORY

1. Introduction: elements, molecules, physical environment and bioenergetics of living beings.

The chemical logic of biological processes. Chemical elements in living species. Biomolecules: general characteristics. Biological importance of water. Non-covalent interactions in water. Ionization of water, ionic balance and buffer systems. Energy transformations in living organisms and the laws of thermodynamics. Free energy and equilibrium constant. Universal biochemical processes and reactions.

2. Proteins: primary structure and biological functions.

Classes of proteins and their functions. Structure and properties of amino acids. Stereoisomerism and acid - base behavior. Peptides and peptide bond. Protein sequence: analysis and evolutionary implications.

3. Three-dimensional structure of proteins.

General concepts. Secondary structure: α helices and β sheets. Tertiary structure: fibrous proteins and globular proteins. Protein folding and its determinant factors. Quaternary structure. Molecular chaperones; Proteasome. Introduction to conformational diseases. Protein structure prediction. Introduction to techniques for purification and characterization of proteins.

4. Structure-function relationship and evolution of proteins.

Storage and transport of oxygen: hemoglobin and myoglobin. Allosterism and cooperativity in hemoglobin. Myoglobin and hemoglobin s examples of protein evolution. Using protein sequences for the analysis of evolutionary relationships.

5. Biological catalysts.

What they are and how they work. Enzyme cofactors. Classification and nomenclature of enzymes. Effects of catalysts in chemical reactions. Examples of enzymatic mechanisms. Enzyme kinetics: the concept of initial velocity; Michaelis-Menten model. Enzyme inhibition. Regulation of enzyme activity: (inhibition), allosterism, covalent modification. Biomedical and biotechnological applications.

6. Carbohydrates.

Types of carbohydrates and their functions. Monosaccharides: Description and properties. Derivatives of monosaccharides. Glycosidic bond. Oligosaccharides. Structural and storage polysaccharides. Glycoconjugates: glycoproteins, proteoglycans, and glycolipids. Carbohydrates as "informative" molecules.

7. Nucleic acids.

Basic concepts. Nucleotides. Primary structure of nucleic acids. Secondary structure: Watson and Crick model and alternative structures. Tertiary structure: DNA supercoiling and tRNA conformation. DNA-protein complexes: chromosome organization.

8. Structural characterization of macromolecules.

Spectroscopic methods and their applications; absorption spectroscopy, fluorescence, circular dichroism, infrared spectroscopy. Mass spectrometry. Determining the three-dimensional structure of macromolecules by NMR and X-ray diffraction.

9. Recombinant DNA.

Brief introduction to nucleic acid metabolism: replication, transcription and translation. Materials and methods for DNA cloning: restriction enzymes, vectors, recombinant protein expression and purification methods. The most common methods of recombinant DNA technology. Applications to the production and modification of proteins. DNA sequencing and genome projects. Some applications of genetic engineering. Genomics and proteomics.

10. Lipids and biological membranes.

Lipid and functions. Lipid storage. Structural membrane lipids. Other lipids with specific biological activity. Lipoproteins. Structure and properties of biological membranes. Membrane proteins. Transport through membranes.

PROBLEMS

This section will be based on a dossier that will be delivered at the beginning of the semester consisting of a series of problems related to the topics developed in the theory lectures. The characteristics of the various parts of the syllabus theory impose a concentration of the problems proposed on certain specific aspects: chemical balance and buffer systems, free energy and equilibrium constant, purification methods and analysis of macromolecules, enzyme kinetics and recombinant DNA.

LABORATORY

Two four-hour sessions:

1- Spectrophotometry as a method for determining the concentration of biomolecules. Preparation of buffer solutions.

2. Liquid chromatography and electrophoresis on SDS-polyacrylamide gels as methods for the analysis and purification of biomolecules.

Methodology

The training activities are divided into three sections: theory classes, problem classes and laboratory practices, each with its specific methodology. These activities can be complemented with a series of tutoring sessions programmable by common agreement between students and teachers.

Theory classes

The teacher will explain the contents of the syllabus with the support of audiovisual material that will be available to students in the Virtual Campus of the subject before the beginning of each of the course topics. These expository sessions will be the most important part of the theory section. It is recommended that students have the material published on the CV in printed form to follow the classes more comfortably and regularly consult the books recommended in the Bibliography.

The theory classes will mostly take the format of expository classes. However, in order to boost teaching, alternative methodologies such as inverse classes, proposals for questionnaires on parts of the syllabus prepared by self-study or on-line mini-tests during some of the theory sessions may be used.

Problem-based learning

The group will be divided into two subgroups whose lists will be made public at the beginning of the course and each person will attend the sessions programmed by their group.

At the beginning of the semester, a dossier of problems will be delivered through the Virtual Campus, to be resolved throughout the sessions. In a limited number of sessions, the problems teacher will expose the experimental and calculation principles necessary to work on them, explaining the guidelines for their resolution and imparting at the same time a part of the complementary subject to the theory classes.

The problems will be prepared after school hours, in working groups of four to five people that will be maintained throughout the course. The non-expository face-to-face sessions will be devoted to solving problems previously worked on in groups, which will be exposed on the board by members of the different work groups. All groups will have the opportunity to publicly explain their proposals for solving problems throughout the semester; sometimes, the resolution sheet of some of the problems will be collected at the end of the class. Additionally, new problems will be proposed that will have to be be worked out in groups in the classroom and whose resolution will have to be delivered at the end of the session. At the end of the course, the members of the working group will also be asked to answer a questionnaire through the Virtual Campus to evaluate their own work and that of their group fellows.

Laboratory practices

The group will be subdivided into four subgroups, whose lists will be announced in advance. To ensure the proper functioning of the practical sessions, only changes that are clearly motivated and previously accepted by the professors of practices will be accepted. As a general rule, substitutions other than those involving the exchange of one student with another from a different group are not accepted. It is compulsory to wear a lab coat, to bring splash goggles and to have the practice protocol (available on the Virtual Campus) printed and previously read; students must also have a notebookto record the observations made and the data obtained.

The practices, as well as their evaluation, will be carried out in groups of two people. After each session a questionnaire will be submitted with the results of the experiment and the answers to the questions posed. Attendance at the practices is mandatory, except in cases where there is a justified, documented cause.

Tutorials

The scheduling of these sessions will always be at the students' request, through their representatives, or at the proposal of the teacher, since they are not explicitly programmed in the teaching calendar. The objective of these sessions, if they are done, is to solve doubts, review basic concepts not explained in class, guide about the sources of information consulted and carry out debates on subjects for which there is programmed autonomous learning or that have been proposed by the teachers. These sessions will not be expository, nor will they advance on the official agenda, but will be sessions for debate and discussion. Its programming will be agreed with the group-class, so that the different sessions are distributed in a balanced way throughout the whole agenda.

Material available to the Virtual Campus of the subject

- Teaching guide
- Presentations used by the teacher in theory classes
- Dossier of problems
- Protocols of practical classes
- Additional self-learning documentation to the theory classes (if necessary)
- Calendar of teaching activities (classroom classes, laboratory classes, tutorials, evaluations, deliveries ...)
- Summary-model of test questions.

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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Laboratory practicals	8	0.32	2, 8, 11, 3
Problem sessions	10	0.4	2, 8, 11, 5
Theory sessions	32	1.28	8, 9, 7, 11, 10, 5
Type: Supervised			
In-class tutorials	6	0.24	9, 7, 11, 10, 5
Self-learning exercises	5	0.2	2, 8, 11, 3
Type: Autonomous			
Deliveries through the CV	7	0.28	2, 8, 11, 3
Group work for problem solving	14	0.56	2, 8, 11, 3, 5
Individual or group study	60	2.4	8, 9, 7, 11, 10, 3, 5

Assessment

The evaluation of this subject is continuous with several types of assessment: partial tests with multiple-answer questions and short-answer questions, in-class resolution of online mini-tests, deliveries through the Virtual Campus, presentation and deliveries in problems class and practical sessions. The objective of the continuous evaluation is to encourage the effort of the students throughout the entire course, allowing to calibrate their degree of monitoring, understanding and integration of the subject. The details of the evaluation methodology are presented in the following section.

Theory

Individual assessment by:

- Three partial tests with multiple-answer questions and short-answer questions. The multiple-choice questions will refer to the part of the syllabus seen in each of the partials. The short answer questions will also refer to it, although to answer the questions of the second and third partials - especially the latter -it may be necessary to refer to previously incorporated concepts. In this way, the section of short answer questions allows to evaluate the integration of the concepts and contemplate the subject as a unit of knowledge.

  Each of the three partial exams will count 18% of the final grade of the subject.

  The two parts of the first two partial exams (multiple choice questions and short answer questions) willaccount for 75% and 25% of the exam grade, respectively. These percentages will be 60% and 40% respectively in the third partial exam.

  Together with the third partial exam, the resolution of a problem previously not worked in class will be proposed as a complement to the evaluation of this teaching typology (see section Problems).

  The partial tests are eliminatory and all students who have achieved the pass after the third partial will have already finished their evaluation of the subject.

  Conditions are not established to attend any of the scheduled tests.

The minimum grade to consider passed a partial exam is a 3.5/10. See the section Global assessment and resit process to read an explanation about the calculation of the global course grade, the minimum necessary to pass the subject and the recovery process.

- Delivery of answers to exercises and questions raised through the CV. This part will count 5% in the calculation of the final marks

Overall, the weight of the theory section in the assessment will be 65% of the total: 54% corresponding to the three partial exams, and 5% corresponding to the deliveries through the Virtual Campus.

Problems

Group assessment with an additional component of individual evaluation:

- Resolution of the problems worked in group throughout the course and exhibition in class, scheduled so that all groups have the opportunity to solve exercises on the board.
- Group resolution of problems proposedin the classroom.

The grade obtained in these two sections, initially the same for all members of the group, may be weighted from the data of an evaluation questionnaire that each student will make about the work of their group and their own.

- Individual exam where one or two problems previously untreated in class will be resolved and that will be done on the date set for the third partial exam.

The weight of the problem section in the evaluation will be 20% of the total: 15% corresponding to the group evaluation and 11% corresponding to the test proposed in conjunction with the third partial.

Practical laboratory

Group assessment:

- Presentation of the results obtained during the practical sessions and resolution of the proposed questionnaire. The attitude and behavior during the laboratory will also be taken into account.

Attendance at laboratory practices is mandatory. Group changes will be only exceptionally admitted, provided the existence of documentary justification. In case of justified absence to one of the practical sessions and not having the option to be present it in a group different from the one assigned, the session will not be considered in the calculation of the practice note.

The weight of the practices section in the evaluation will be 15% of the total.

Global assessment and resit process

The three sections are inseparable and the student must participate, and be evaluated, in all of them to pass the subject. The final grade is calculated according to the percentages explained above; Thus, the theory section accounts for 65% of the overall grade, the problems section for 20% and the practical lab work the remaining 15%.

Student will successfully pass the subject when the following three conditions are met:

- A minimum of 3.5 in the three partial exams.
- A minimum of 4 in the global theory mark (global theory mark = (average mark of partial exams x 0.54 + mark in CV deliveries x 0.05)/0.65).
- A minimum of 5/10 resulting from the addition of the theory, problems and practical marks.

Students who do not meet these conditions will be offered a resit examination that will be scheduled after the third partial exam. In order to participate in the resit exam, students must have been previously evaluated in a set of activities whose total weight equals a minimum of two thirds of the total grade of the subject.

The resit exam will contain multiple answer questions corresponding to the three partial exams of the subject and a written test of short questions that will cover the whole syllabus. Students will have to answer the multiple choice questions of, at least, those partial exams where they did not reach a 3.5/10 and also the short questions section. They may, however, choose to answer the questions from other parts of the exam, in which case they will be presumed to waive the previous grade.

For the calculation of the course grade after the resit exam, each of the four parts (three partial exams with multiple-choice questions and one short question test) will count 25% of the overall mark. The marks obtained in the first instance will be used for the partial exams not included in the resit examination. So as to proceed to the final mark calculation, the global theory mark must be equal or exceed 4 after the resit exam. Otherwise, a mark below 5 or a "No Avaluable" grade will appear in the final record.

This recovery test will also be open to students who have otherwise passed the course already and wish to improve their grades; the same conditions described above apply.

Other considerations

Students who can not attend an individual evaluation test due to a cause such as illness, death of a first degree relative or accident and provide a proving documentation to the Coordination of the Degree and the theory professors, will be entitled to perform the test on another date.

When the continuous assessment activities carried out add up to a weight lower than 67% in the final grade and, therefore, the affected people are not in a position to be able to take the resit exam, the grade will be "No Avaluable".

After the second enrollment of the subject, the students repeating coursemust notattendthe teaching activities or the evaluations of those competences that have been overcome, consistent, in this case, in the group work of cases/problems, the practical sessions, the delivery of work through the CV and the classroom online-tests, given the fact that their previous grades in those parts were 50% of the maximum grade or higher.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Delivery of dossiers / practical sessions questionnaires	15%	0.5	0.02	1, 2, 8, 11, 12, 3, 4
Delivery of home-solved problems and in-class resolution of problems	15%	2	0.08	2, 8, 11, 13
Delivery of self-learning exercises	5%	0.5	0.02	18, 2, 8, 11, 15, 14, 4
Mixed partial tests: multiple answer/short questions	54%	4.5	0.18	19, 6, 9, 7, 10, 17, 16, 3, 4, 5
Problems examination	11%	0.5	0.02	2, 9, 7, 10, 5

Bibliography

Basic bibliografy (alphabetic order):

Nelson, D.L. i Cox, M.M. "Principios de Bioquímica" (2014) 6ª ed. Ed. Omega, Barcelona. Setena edició en anglès: MacMillan, 2017. Setena edició en castellà: Ed. Omega, 2019

Stryer, L, Berg, J.M., Tymoczko, J.L. "Bioquímica" (2013) 7ªed. Ed. Reverté, Barcelona; hi ha una sisena edició de la mateixa editorial en català (2008). New edition in English: MacMillan, 2019.

Tymoczko, J.L., Berg, J.M., Jeremy, M., Stryer, L. "Bioquímica. Curso básico" (2104) 2ª ed. Ed. Reverté, Barcelona.

Voet, D. Voet, J.G., Pratt, C.W. "Fundamentos de Bioquímica" (recurs electrònic) (2016) 4ª ed. Ed. Médica Panamericana.

https://cataleg.uab.cat/iii/encore/record/C__Rb1986458__Sfundamentos%20de%20bioqu%C3%ADmica__Orightı

Web liks

An up-to-date list is found in the Campus Virtual and at:
https://catalegclassic.uab.cat/search*cat/r?SEARCH=100758

Software

PyMol: https://pymol.org/2/

JMol: http://jmol.sourceforge.net/