Universidad Zaragoza

Academic Year/course: 2021/22

27131 - Biophysics

Syllabus Information

Academic Year: 2021/22
Subject: 27131 - Biofísica
Faculty / School: 100 - Facultad de Ciencias
Degree: 446 - Degree in Biotechnology
ECTS: 6.0
Year: 4
Semester: First semester
Subject Type: Optional
Module:

1. General information

1.1. Aims of the course

Biophysics is an interdisciplinary science that applies approaches and methods used in physics to study biological phenomena. Biophysics encompasses all levels of biological organization, from the molecular level to the organism, and populations. This subject focuses on the knowledge of the physical and physico-chemical principles of the behavior of cellular biomolecules with the aim of understanding the regulation of metabolic processes, the processes of transformation of energy or the bioelectric phenomena that sustain the vital functions of cells and organisms.
The general aim of the subject is to teach the students these foundations, particularly those involving proteins and membranes, so that they understand the potential use of biomolecules and biophysical methodologies as powerful tools in biotechnological and biomedical applications.
We will address different aspects of Molecular Biophysics, particularly the stability of biological molecules, the transformation of biological energy and the dynamics of biological processes, making special emphasis on the biophysical mechanisms that lead to relevant cellular signals or the development of conformational diseases. We will also study the biophysics of biological membranes and their particular involvement in cell bioenergetics and bioelectric phenomena in the nervous system.
These approaches and objectives are aligned with the following Sustainable Development Goals (SDGs) of the United Nations Agenda 2030 (https://www.un.org/sustainabledevelopment/es/), so that the acquisition of the learning outcomes of the subject provides training and competence to contribute to some extent to their achievement.
- Goal 3: Health and well-being.
- Goal 7: Affordable and clean energy.
- Goal 9: Industry, innovation and infrastructure

1.2. Context and importance of this course in the degree

Biophysics is taught in the first semester of the fourth year of the Degree in Biotechnology and belongs to the optional training module. It has a workload of 6 ECTS, 3 theoretic and 3 practical (of which 1 ECTS will be practical cases and 2 ECTS laboratory and computer practical activities). At this stage of their degree students already have a strong methodological and theoretical background, and are aware of the potential of biomolecules in biotechnology. In this context, biophysical research shares niche with biochemistry, molecular biology, biomedicine, physiology, nanotechnology, bioengineering, computational biology, biomechanics, developmental biology and systems biology.

Likewise, biophysical methods have multiple applications in the fields of biomedicine and biotechnology.
In this subject the student will acquire general understanding of the biophysical principles of the behavior of proteins and lipid membranes, as well as their modes of interaction and the processes in which they are involved. At the same time, these processes will be linked to the development of biotechnological applications based on these biomolecules.
In the lab sessions, students will put into practice the knowledge acquired in the theoretical sessions and will develop additional laboratory skills associated with the understanding and realization of experimental protocols, the use of instrumental techniques, the search and screening for information and the analysis, discussion and communication of results.

1.3. Recommendations to take this course

* To have completed the following subjects: Structure of Macromolecules, Biochemistry, Molecular Biology, Genetic engineering and Bioinformatics (the last two are recommended but not necessary)
* To perform regular and continued work throughout the course, participating actively in the theoretical classes, practices and tutorials, and solving the exercises and problems.
Students are also encouraged to consult specific books related to the subject, in addition to the material provided by the teacher.

2. Learning goals

2.1. Competences

Upon completion of the course students will be competent for

- Understanding the basic principles of thermodynamics applied to biomolecular interactions and conformational stability.
- Identifying why alterations in the conformational stability of a biomolecule or in its ability to establish interactions with others can be the origin of the development of a disease.
- Understanding the strategies more commonly used by living organisms during the transformation of biological energy.
- Identifying the processes that keep the bioelectric signaling phenomena, particularly in eukaryotic cells, and their regulation.
- Using the knowledge gained as an opportunity to design biotechnological and biomedical tools
- Identifying the basic tools of biophysical methods and their applications, and using them to determine physical and chemical quantitative parameters of biomolecules and biological processes.
- Choosing and using the right biophysical tools to obtain structure-function relationships in biological molecules.
- Designing experiments and critically analyzing results and conclusions.
- Informing, analyzing, and communicating scientific content.
- Using computer tools to obtain, analyze and interpret data, and to understand simple models of biological processes at the molecular level.
- Posing and solving questions and problems in the field of Biophysics related to biotechnological applications.
- Transmitting basic concepts about the methodologies used.
- Planning the application of biophysical methods to modulate the structure-function relationships in biomolecules.
- Interpreting results of physical-chemical and spectroscopic techniques in terms of structure and function of biomolecules.
- Analyzing quantitatively experimental results to determine kinetic or thermodynamic parameters of processes involving biomolecules.

2.2. Learning goals

- To describe and understand the basic principles of thermodynamics applied to the interaction between biological molecules and their conformational stability.
- To determine why changes in conformational stability of biomolecules or in its ability to establish intermolecular interactions are the origin of many human diseases.
- To understand the biophysical principles that govern the stability and function of biological membranes
- To understand the strategies more commonly used by living organisms during transformation of biological energy,

as well as the dynamic and quantum effects that contribute to them.

- To understand the basis of the membrane bioelectric processes and their regulation, particularly those of eukaryotic cells.
- To use the knowledge gained in molecular biophysics to be able to design biotechnological and biomedical applications.
- To identify the basic tools of biophysical methods and their applications, and to use them to quantitatively determine physical and chemical parameters of biomolecules and biological processes.

2.3. Importance of learning goals

Understanding the biophysical principles that govern the cellular processes is of fundamental relevance in order to be able to influence on them in a rational, controlled and efficient manner. In this context, the application of the knowledge on molecular biophysics and the biophysical methodology presented in this subject represents highly valuable theoretical and practical tools in the Biotechnology and Biomedicine sectors, which represent an important part of human activity. In addition, these sectors benefit from professionals with knowledge of the basic principles of different biophysical processes and techniques and their applications not only to understand the relevant cellular processes, but also for the development of biomedical and biotechnological applications with direct impact in the society.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

The student should demonstrate that it has reached the intended learning outcomes reaching a minimum overall score of 5 points out of 10 in each of the proposed assessment activities.
1 **Theory exam.** Written exam at the end of the semester. Specific competences will be assessed through a written exam that includes a part of multiple-choice questions and another part that will correspond to the resolution of short case theoretical issues/exercises. Usually: 20 test questions and 3 short/exercises questions (contribution to the note 40% / 60% respectively). It will be essential to obtain a mark of at least 5 out of 10 in each of these evaluation activities so that they can average together. This exam will take place on dates determined by faculty for this purpose during the official tests schedule. It is scored from 0 to 10.
2 **Hands-on practical cases. Compulsory assistance and compulsory execution.** Continuous assessment during their development. The student will prepare a short report (1 to 2 pages) with results and discussion of each practical issue. Reports will be presented through the Moodle platform at the end of the sessions in the computer class. Only reports submitted through the Moodle platform will be accepted. Those not delivered in time through Moodle platform will only reach a maximum mark of 5 (out of 10). It is scored from 0 to 10.
3 **Resolution of exercises.** Continuous assessment during exercise classes. Active participation during the resolution and discussion of the different exercises during face-to-face classes will be scored from 0 to 1.
4 **General.** Students must pass theory and practice (case studies + individual project) with a minimum mark of 5 out of 10, respectively.
5 **Calculation of final mark and requirements to overcome the subject:**

- Final mark: Theory exam (80%) + practical studies (20%). Students can add up to 1 additional point for their active participation in the classes of exercises and in the discussions in master clases.
- To overcome the course is indispensable to have 5 out of 10, both in the theory exam and practical case studies.
- Fraud and total or partial plagiarism in any of the evaluation tests (including reports of practical sessions) will result in the failing of the subject with the minimum mark, besides the disciplinary action taken by the Commission of Guarantees for these cases.

In addition to the designated evaluation mode, those students that do not assist to the practical mandatory sessions or do not submit reports should pass a **global test**, which will judge the

attainment of the learning outcomes outlined above. This test will consist on i) the theory examination on the same date and time as the rest of class mates and ii) an additional test of data analysis with the computer related with the practical cases. These two evaluation tasks will contribute to the final mark 50%/50% respectively.

Dates will be determined by the faculty.
The syllabus that students should use to prepare the different tests is in the section 'Program' of this same teaching guide.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

Master classes. Face-to-face (3 ECTS). Projections of computer screen, including small animations, videos and online navigations will be used. The basic material will be provided to students through blended learning platform Moodle UNIZAR. Semi-present methodologies will be used to exchange information with the students.
Resolution of exercises. Face-to-face (1 ECTS). They will be interspersed with theoretical classes and the students will be responsible for the resolution of exercises previously provided by the professor. This part of the course requires teamwork and/or individual from the learner who has to solve the problems after the theoretical sessions and prior to face-to-face sessions.
Hands-on practical cases. Face-to-face and mandatory (2 ECTS). Laboratory and computer room. Students will conduct a series of 3 wet lab practices. These sessions will be followed by 2 others in the computer room where the results will be analyzed quantitatively and debated by the group. After the debate students will proceed to the elaboration of an individual report during the same session.

4.2. Learning tasks

MASTER CLASSES.
On campus. 3 ECTS credits (30 hours). Teachers will present the basic theoretical knowledge of the subject.
RESOLUTION OF EXERCISES.
On campus. 1 ECTS (10 hours). The student will apply the knowledge acquired in the classroom through the resolution of exercises. The Professor will share problems through the Moodle learning platform. In these sessions students will solve the problems, and the results will be discussed with the rest of the class and the teacher. Especially the board will be used. These activities will allow students to acquire the ability and skills needed to analyze and resolve problems related to the contents of the subject.
HANDS-ON PRACTICAL CASES. Face-to-face and mandatory. 2 ECTS (20 hours). The program will include 5 sessions of 4 hours. Three of these sessions will be conducted in the laboratory and the last two in the computer room. The teacher will distribute practical cases through the learning platform, will instruct the student in how to design and carry out experiments, and then how to deal with data, performing calculations and interpreting the results. These activities will help the student to acquire the ability and skills needed to analyze and resolve particular problems. The analysis of the results should lead to the preparation of a summary and their interpretation, within the schedule of the sessions in the computer room. This activity will encourage students to use different tools that they already know from other subjects or have been explained in the master classes. It will also stimulate the use by students of scientific material on network, to discuss and communicate their findings, knowledge and latest reasons underpinning them.

"Teaching and evaluation activities will be carried out in face-to-face mode, unless, due to the health situation, the rules issued by the competent authorities and the University of Zaragoza have them carried out on-line."

4.3. Syllabus

MASTER CLASSES

Molecular Biophysics

Theme 1. Principles of thermodynamics applied to biological systems.
Theme 2. Macromolecules: conformational and association equilibria. Conformational diseases and development of molecular chaperone-mediated strategies.
Theme 3. Macromolecules: biochemical balances in the cellular environment; macromolecular crowding, partition in different microenvironments, compartmentalization within membrane and membraneless organelles.

Bioenergetics and Biophotonics: biological tools and biotechnological potential

Theme 4. Transport across biological membranes.
Theme 5. Transformation of biological energy: compounds rich in energy, gradients of ion concentration, electron transfer and electromagnetic radiation as biological energy sources.
Theme 6. Kinetics and dynamics of cellular bioenergetics.
Theme 7. From molecular biophysics and bioenergetics to the design of biotechnological and biomedical tools.

Neuroscience and Bioelectric phenomena

Theme 8. Ion channels and action potential. Transmitance of the nerve impulse along the axon.
Theme 9. Neurotransmission through synapses. Chemical synapses: fusion of vesicles, release of neurotransmitters and postsynaptic receptors (AMPA, GABA, Ach). Electrical synapses. Biophysical methods in neuroscience: Patch-clamp and super-resolution imaging.
Theme 10. Sensory reception.

RESOLUTION OF EXERCISES.

They will correspond to the topics of the master classes, will include theoretical questions and numerical exercises and will be interspersed with the master classes.

HANDS-ON PRACTICAL CASES

Case 1: Apomyoglobin preparation and determination of the myoglobin extinction coefficient.

Case 2: Experimental determination of the heme-apomyoglobin dissociation constant by differential spectroscopy.

Case 3: Preparation of liposomes. Transformation of liposomes.

Case 4: Data analysis of cases 1-3. Obtaining parameters of interaction (nonlinear fittings). Statistical evaluation of experimental data.

Case 5: Bioelectric phenomena. Analysis of a case and debate.

4.4. Course planning and calendar

Teaching calendar will coincide with the established officially and presented at the master timetable in the classroom for students of the fourth course of the Degree in biotechnology. The Coordinator of the degree will produce groups of practices at beginning of course to not produce overlaps with other subjects. Activities schedules will be made public through TABLON DE ANUNCIOS GRADO BIOTECNOLOGÍA in Moodle and at the Moodle course for Biophysics. Moodle will be also used to communicate enrolled students about the coordination and distribution in hands-on practice groups. Provisional dates will be available on the website of the Faculty of Sciences in the corresponding section of the Degree in Biotechnology: https://ciencias.unizar.es/grado-en-biotecnologia. In this web the calls for January/February and September test dates will be available also.

4.5. Bibliography and recommended resources

http://biblos.unizar.es/br/br_citas.php?codigo=27131&year=2020