Universitat Autònoma de Barcelona

2022/2023

Introduction to Biophysics

Code: 100165
ECTS Credits: 5

Degree	Type	Year	Semester
2500097 Physics	OT	3	1

Contact

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Use of Languages

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

Other comments on languages

A l'assignatura es traballaran textos i vídeos científics en anglès

Teachers

Juan Camacho Castro

Prerequisites

It is advisable to have some general knowledge aon chemistry and biology, at a high school level.

The fields of physics most employed during the course will be Thermodynamics, Elasticity, Electricity and Magnetism. So that, it is advisable to have followed courses on these topics in the previous years of the degree. In particular, students should have followed courses on theor second year the courses on 'Electromagnetism' and 'Matter Structure and Thermodynamics'.

Objectives and Contextualisation

This course tries to provide a panoramic, but not exhaustive, introduction to biophysics. The main goal is that physics students have a first touch of physical analysis of problems that lie at the fontier with biology (and, often, with biochemistry), and become aware of the richness of problems in biology for which the tools and methods from physics are extremely worthy. Likewise, the course introduces several ideas at a basic level that can help the students to face in the future more advances courses related to biology, biotechnology, bioinformatics or complex systems.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Apply fundamental principles to the qualitative and quantitative study of various specific areas in physics

- Be familiar with the bases of certain advanced topics, including current developments on the parameters of physics that one could subsequently develop more fully
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Develop the capacity for analysis and synthesis that allows the acquisition of knowledge and skills in different fields of physics, and apply to these fields the skills inherent within the degree of physics, contributing innovative and competitive proposals.
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project

Learning Outcomes

1. Apply the power-cord model to the description of the shape and speed of action potential in excitable membranes.
2. Calculate Nernst's potential in physical and biological systems.
3. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
4. Correctly apply the equations of passive and active transport to the propagation of nerve signals in excitable membranes.
5. Describe the bases to synchrotron radiation and its application to protein structure.
6. Describe the basic ideas of learning in neural networks and the principal morphological and functional characteristics of the brain.
7. Describe the basic steps in protein synthesis and the genetic code.
8. Describe the fundamentals of certain medical imaging techniques (MRI, PET, CT).
9. Describe the principal basic techniques of medical physics.
10. Describe the principal unresolved problems in biophysics (protein folding, physical sequencing of DNA, the physical bases of genetic and epigenetic code, molecular motors, neural networks).
11. Develop an understanding of the bases to biomedical observation techniques (electrocardiography, electroencephalography and magnetoencephalography).
12. Distinguish the fields of application for different types of microscope (optical, electronic, tunneling or atomic force).
13. Establish the basic concepts of physics membranes and active and passive transport, and apply these to the action potential in the nervous system.
14. Establish the basic physical aspects of proteins and nucleic acids.
15. Explain the explicit or implicit code of practice of one's own area of knowledge.
16. Identify situations in which a change or improvement is needed.
17. Identify the social, economic and environmental implications of academic and professional activities within one's own area of knowledge.
18. Model various biological processes (growth of tumors, cardiac excitation waves, learning in neural networks, immune system).
19. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
20. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
21. Work on problems of the dosimetry of ionizing radiation and its biological effects for subsequent training in medical physics.

Content

Program

1. Chemical foundatiosn of biophysics.

2. Physics of macromolecules.
3. The central dogma of biology.
4. Introduction to cellular physics.
5. Introduction to neurophysics.
6. Morphogenesis, evolution and ecosystems.
7. Biomechanics and bioenergetics.

Methodology

We start the course by reviewing the essential properties of macromolecules, centering our attention on proteins and DNA (their elements, structure, and mechanical and electrical properties). Then we study some physical aspects of macromolecules, focused on molecular pumps and engines. At the cell level, we introduce basic ideas about metabolism, and the main structural and transport properties of the cell membrane, with a special emphasis given to the behavior of the neuronal system (individual neurons, networks, and the brain). Finally we introduce several basic ideas about population dynamics and evolution, and the role that physics play in the latter (in particular how evolution have found solutions to overcome the physical difficulties to the movement or to the energy income of living organisms).

Lessons of theory will be based on a methodology in which every day some previous material will be avilable (in video or pdf) as an introduction to the topic that will be discussed and presented in the class. Also, some questions will be posed in that material in order to promote an online discussion through the Moodle room. These online dicussions will atually be part of the evaluation activities of the course. At the end of each topic, some optional exercises will be proposed for the students to check if they have satisfactorily understood the essential concepts of that topic.

Practical lessons will be used to discuss in group and solve the exercises from the main list of the course.

We will employ 15 minutes from the last session of the course to let the students answer the instituional survey about the course.

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			
Practical classes	14	0.56	4, 1, 2, 18
Theoretical classes	27	1.08	11, 8, 5, 7, 10, 6, 9, 12, 14, 13, 19, 21
Type: Autonomous			
Mentoring sessions	5	0.2	18
Project and autonomous exercises	18	0.72	1, 2, 10, 18, 21
Study	53	2.12	11, 8, 5, 7, 10, 6, 9, 12, 14, 13

Assessment

Partial exams: Two partial exams during the course, the second having a larger weight on the final mark (since the quantity of contents in it will be also larger).

Presentation project: It consists of a project (in groups of two students, with a different topic for each group) about a topic of current relevance in biophysics. This activity will have the form of an oral presentation to be recorded by the students in video (equipments and resources necessary for it will be available).

Participation in the discussion forums: To evaluate the continous work of the student during the course, the participation (both in terms of constancy and through the level of the contributions) in the discussion forums that will be open in the Moodle room throughout the course will be taken into account.

To pass the course it is necessary to have a global mark of 5 (over 10) and having obtained a minimum mark of 3,5 in each of the two partial exams.

Those students that have taken the partial exams but have not obtained the minimum mark of 3,5 (or those who have not obtained a final mark of 5) have the option to attend a referral exam.

The Presentation project and the participation in the discussions will be considered as activities that cannot be re-assessed.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Partial exam 1	35/100	2	0.08	4, 1, 2, 11, 8, 5, 7, 10, 6, 9, 12, 14, 13, 18, 19, 21
Partial exam 2	40/100	2	0.08	4, 1, 2, 11, 8, 5, 7, 10, 6, 9, 12, 14, 13, 18, 21
Participation in the discussion forums	10/100	2	0.08	3, 15, 17, 16, 19, 20
Presentation project	15/100	2	0.08	3, 15, 17, 19, 20

Bibliography

Main references

P. Nelson, *Física biológica*, Ed. Reverté, Barcelona, 2005 (disponible online a través de la biblioteca UAB)

F. Cleri. *The physics of Living Systems*. Springer-Verlag, 2016 (disponible online a través de la biblioteca UAB)

R. Phillips, J. Kondev, J. Theriot, H. G. García, *Physical biology of the cell*, (Garland Science, 2013)

J. Kuriyan, B. Konforti and D. Wemmer. *The molecules of life* (Garland Science, 2013)

Basic introdutions to physics for biologists

F. Cussó, C. López and R. Villar, *Física de los procesos biológicos*, Ariel, Barcelona,

2004

D. Jou, J. E. Llebot i C. Pérez-García, *Física para las ciencias de la vida*, Mc Graw

Hill, Madrid, 1994

T.M. Nordlund. *Quantitative understanding of biosystems*. (CRC Press, 2011)

M. Ortuño, *Física para biología, medicina, veterinaria y farmacia*, Crítica, Barcelona,

1996

J. W. Kane i M. M. Sternheim, *Física para las ciencias de la vida*, Reverté, Barcelona,

1987

B. B. Benedek and F.M.H. Villars, *Physics, with illustrative examples from biology* (3

vols), Addison-Wesley, 1979

Advanced and complementary references on biophysics

T. F. Weiss, *Cellular biophysics* (2 vols), Bradford Books, MIT Press, Cambridge, 1996

R.K. Hobbie, *Intermediate physics for medicine and biology.* Wiley, 1978

W. Bialek. *Biophysics: Searching for principles*. Princeton Univ. Press, 2012

C. Blomberg. *Physics of life*. Elsevier, 2007

R. Cotterill. *Biophysics. An introduction*. John Wiley & Sons, 2002

J.L. Nadeau. *Introduction to ExperimentalBiophysics*. CRC PRess, 2018

D. Johnston and S.M.-S. Wu. *Foundations of cellular neurophysiology*. MIT Press, 1995

Software

This course does not require the use of any specific software.

Only for the presentation in video, software of broacasting and edition (OBS; Shotcut, ...) will be necessary.