Universidad Zaragoza

Academic Year/course: 2024/25

68459 - Modelling of Biological Systems

Syllabus Information

Academic year: 2024/25
Subject: 68459 - Modelling of Biological Systems
Faculty / School: 100 - Facultad de Ciencias
Degree: 626 - Máster Universitario en Biofísica y Biotecnología Cuantitativa / Master in Biophysics and Quantitative Biotechnology
ECTS: 6.0
Year: 01
Semester: Second semester
Subject type: Optional
Module:

1. General information

This course presents the main theoretical and computational tools to model biological systems from a physical viewpoint. It builds up on the knowledge from “Systems and Synthetic Biology” and “Simulations of Biomolecules”, to:

- present the dynamical and thermodynamic description of biological systems, focusing on the most relevant approaches.
- introduce the appropriate models for the different scales and processes, and the computational tools that allow to connect them with the experimental data.
- provide the student with an educated criterion to choose the most suitable method for each situation, and to be able to critically evaluate the model predictions.

Together with the course “Biostatistics and Bioinformatics” and “Big Data in Biology”, this course covers the most theoretical aspects of the master program.

2. Learning results

The main goal of the course is to provide the student with the ability to manage theoretical models and computational methods to describe a biological system, since this is an essential skill for a research career within this field. At the end of the course, the student will be able to design a simulation of a biological system with the most adequate tools for each case. In more details, specific learning goals are:

- To know the theoretical / computational tools essential to rationalize the experimental data obtained in the study of biological systems.
- To know the fundamental aspects of both the dynamical and thermodynamic description of biological systems, the relevant theories and related equations.
- To know the most used models for the description of different scales and biological processes, and the simulation techniques that allow to relate the models with the experimental outcomes.
- To know how to select the most appropriate method for each particular case as well as critically evaluate the results obtained or those found in the scientific literature.

3. Syllabus

1. Statistical mechanics models I: statistical ensembles.
2. Statistical mechanics models II: Cooperativity and phase transitions
3. Statistical mechanics models III: Models of biopolymers.
4. Statistical mechanics models IV: Coarse graining and force fields.
5. Statistical mechanics models V: DNA and Protein Models.
6. Stochastic models I: Brownian motion and diffusion.
7. Stochastic models II: Langevin and Fokker-Planck equations.
8. Stochastic models III: Chemical master equation and Gillespie algorithm.
9. Stochastic models IV: Kramers theory.
10. Simulation techniques: Monte Carlo methods and applications.

11. Introduction to Epidemics: Models and Methods in Networks and applications

The course is held during the 2nd semester of the academic year, according to the official calendar at https://ciencias.unizar.es/calendario-y-horarios.

4. Academic activities

- lectures (35 hours),
- exercises on relevant examples and practice sessions in the computer laboratory (25 hours)
- personal work on the proposed exercises/practices and preparation of the reports (50)
- personal study (38)
- evaluation 2 hours

Optional assignments will be provided to the students interested in deepening their understanding in specific topics.

Students are expected to participate actively throughout all the activities.

Course material: the Moodle platform will be used to distribute lecture notes, as well as to propose exercises and tests.

5. Assessment system

1: (65% of the final grade). Continuous evaluation of the student's progress by direct interaction in the classroom, rewarding active participation during the lectures, with special emphasis on the reports and defenses related to the practice sessions and to the proposed exercises.

2: (35% of the final grade) Final exam, with a set of questions on the topics exposed in the theoretical classes. Students should pass the exam with at least 40% of the total score (4/10) in order to pass the course.

6. Sustainable Development Goals

3 - Good Health & Well-Being