COURSE DATA

DATA SUBJECT

Code: 36354
Name: System Biology
Cycle: Undergraduate Studies
ECTS Credits: 6
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
1109 - Degree in Biochemistry and Biomedical Sciences	Facultat de Ciències Biològiques	4	Annual

SUBJECT-MATTER

Degree	Subject-matter	Character
1109 - Degree in Biochemistry and Biomedical Sciences	Materia de asignaturas optativas	ELECTIVES

COORDINATION

MARIN NAVARRO JULIA VICTORIA

SUMMARY

Systems Biology is an optional course included in the Biochemistry and Biomedical Sciences degree syllabus whose main goal is to acquaint the students with a perspective of living beings at the molecular and cellular level in which interrelations between constituent elements are remarked, functional consequences of these relations are analyzed, quantitative aspects are highlighted and the need for mathematical modelling to handle the complexity of life is emphasized. This approach is relatively new to the students because, after assuming that the descriptive contents of matters such as Biochemistry, Cell Biology and Genetics are already mastered, further abstraction is made to generalize functional aspects, analyzing their advantages and limitations as seen through the eyes of an engineer. The goal is not so much to describe living beings but rather to abstract, from their complex description, the crucial constitutive elements in order to find out the underlying functional logic. In this regard, the promising field that has been recently opened by the so called \"Synthetic Biology\", which aims to produce \"design\" organisms tailored to new properties of industrial, therapeutical or social interest, should be remarked. This topic is, without doubt, of great interest for the molecular biologist but also asks for a retaking of some mathematical and physical foundations which, even if already studied in the past, may have been parly forgotten because of their reduced appearance in other courses. Therefore, this course starts with a review of basic concepts to be subsequently applied to biological problems of increasing complexity.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

No specialized knowledge of Mathematics or Physics is required beyond the matters studied in the first course of the degree, but a certain sympathy (or, at least, absence of hostility) to these disciplines is desirable. Full profit of the course requires also the understanding of English at the level of scientific text reading.

COMPETENCES / LEARNING OUTCOMES

1109 - Degree in Biochemistry and Biomedical Sciences

Be able to think in an integrated manner and approach problems from different perspectives.

Capacidad para la asimilación de textos científicos en inglés.

Know how to design multidisciplinary experimental strategies in the field of molecular biosciences to solve complex biological problems, especially those related to human health.

Know how to use mathematical and statistical tools to solve biological problems.

Know how to use the different bibliographic sources and biological databases and be able to use bioinformatic tools.

Know the biochemical and molecular bases of cell function.

Know the chemical and physical principles that determine the properties of biological molecules and govern the reactions in which they are involved.

Know the structural and functional characteristics of macromolecules.

DESCRIPTION OF CONTENTS

1. Basic concepts.

Introduction to Systems Biology. Mathematical and physical concepts useful in Biology. Temporal and spatio-temporal dynamical systems.

2. One-dimension systems modeling.

Deterministic models in time differential equations. Steady states and stability. Hysteresis cycles.

Bifurcations. Reversible and irreversible toggle switch circuits.

3. Two or more dimensions systems modeling.

Analysis of steady states and stability. Analysis of phasic portraits. Limit cycles and self-sustained oscillations. Non-dimensionalization of systems. Dynamic chaos.

4. Probability and biological noise.

Tendency parameters and probability density functions. Model distributions. Types of noise and their description. Autocorrelation function and frequency analysis. Origin of biological noise. Sensory perception and noise.

5. Statistical mechanics and kinetics.

Boltzmann distribution. Kinetic and thermodynamic consequences. Analysis of non-elementary kinetics. Cyclic flows and detailed balance.

6. **Processes in space and time.**

Partial differential equations. Random walk and diffussion laws. Time to capture. Diffussion and reaction-diffussion models.

7. Cybernetics.

Frequency response of a system. Feedback. Analysis of regulatory circuits. Homeostatic circuits and damping of fluctuations. Circuits for perception of stimuli. Oscillatory circuits.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	45,00
Classroom practices	15,00
Total hours	**60,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	15,00
Preparation of lessons	35,00

Preparation for assessment activities	40,00
Resolution of case studies	0,00
Total hours	**90,00**

TEACHING METHODOLOGY

The matter will be taught as a series of one-hour long classroom lectures. These lectures will include the exposition of new concepts and of examples of application of these concepts to biological modeling. Theoretical considerations will be frequently interrupted to apply them to practical cases (requiring calculations), treated as problems that will be solved in detail. In parallel, some other problems will be raised and left to the students as homework to be solved (with the teacher's advice) with the guide of the theory and problems discussed in the classroom, and/or using additional bibliography that the teacher may suggest.

Because the course relies on the progressive assimilation of a number of fundamental concepts that should be mastered to allow further advance, evaluation will be continuous along the course to promote a persistent attention to the matter by the students.

EVALUATION

Objective tests on the contents of the subject (100%).

A continuous evaluation is proposed through short written exams taking place abour every four weeks. The matter covered by each exam will not be eliminated but will accumulate along the course. Alternatively, for those students not passing the continuous evaluation, there will be a final exam covering the matter of the whole course.

Exams will include theoretical questions and problems (that, in some occasions, might be solved with the help of books and classnotes). In both cases not only knowledge will be evaluated but also the ability to apply it to the modelling of biological problems while extracting relevant conclusions from the models. To that end, all exams will include at least a biological case that the student will have to modelize, proposing equations based on relevant interactions, analyzing the consequences of the model and contrasting its predictions with the expected biological response. Exams will be graded up to 10 points, while 5 points (either as an average of the periodic short exams along the course or as a score of the final exam) are needed to pass the course.

REFERENCES

- ALON, U. An introduction to Systems Biology: Design principles of biological circuits. Chapman & Hall/CRC, 2007.

- COVERT, M.W. Fundamentals of Systems Biology. CRC Press, 2014.

- DiSTEFANO, J. Dynamic Systems Biology Modeling and Simulation. Elsevier, 2013.
- FALL, C.P., MARLAND, E.S., WAGNER, J.M. y TYSON, J.J. Computational Cell Biology. Springer, 2002
- INGALLS, B.P. Mathematical Modeling in Systems Biology. MIT Press, 2013.
- PHILLIPS, R., KONDEV, J., THERIOT, J. y GARCÍA, H.G. Physical Biology of the Cell. 2nd ed. Garland Science, 2012.
- VOIT, E. A first course in Systems Biology. Garland Science, 2012.
- BEARD, D.A. Biosimulation. Cambridge University Press, 2012.
- EDELSTEIN-KESHET, L. Mathematical models in biology. McGraw & Hill, 1988.
- NELSON, P. Physical Models of Living Systems. W.H. Freeman & Co., 2015.
- PALSSON, B.Ø. Systems biology: Simulation of dynamic network states. Cambridge University Press, 2011.
- SNEPPEN,K. Models of life: Dynamics and regulation in biological systems. Cambridge University Press, 2014
- Van den BERG, H. Mathematical models of biological Systems. Oxford University Press, 2011.
- SEGEL, L.A. y EDELSTEIN-KESHET, L. A primer on mathematical models in Biology. SIAM Press, 2013.