COURSE DATA

DATA SUBJECT

Code: 36885
Name: Systems biology
Cycle: Undergraduate Studies
ECTS Credits: 4.5
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
1111 - Grado en Biotecnología	Facultat de Ciències Biològiques	4	Annual

SUBJECT-MATTER

Degree	Subject-matter	Character
1111 - Grado en Biotecnología	Optability	ELECTIVES

COORDINATION

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SUMMARY

The Systems Biology course is an optional subject of the Biotechnology degree. The main objective is to familiarize the student with a way of studying the living environment at the molecular and cellular level in which the interdependent relationships between the constituent elements are highlighted and the functional consequences of these interactions are analyzed, giving priority to the quantitative aspects and the need for mathematical modeling, in order to address the complexity of living organisms. This is a relatively new vision for the student in which, considering the descriptive contents of subjects such as Biochemistry, Cell Biology and Genetics, an abstraction is made that seeks to generalize the functional aspects and to analyze their advantages and limitations by means of mathematical modeling using the perspective of an engineer. The objective is not to describe the living being but to extract, from its complex description, the essential elements and to imagine the underlying functional logic. In this sense, it is worth mentioning the promising field recently opened up by the so-called Synthetic Biology, which aims to produce ¿designer¿ organisms with new properties of industrial, therapeutic or social utility. This approach is undoubtedly of great interest to a molecular biologist, but it requires a re-familiarization with mathematical and physical bases that, although known to the students, have not been used frequently in most of the subjects that make up the curriculum of the degree, and may have been partially forgotten. In this sense, the course recalls these basic concepts and then applies them to biological situations 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 special knowledge of Mathematics or Physics outside of what is taught in the first year of the degree is necessary, but a certain sympathy (or, at least, absence of rejection) towards these disciplines is desirable.

COMPETENCES / LEARNING OUTCOMES

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Actuar con autonomía en el aprendizaje, tomando decisiones fundamentadas en diferentes contextos, emitiendo juicios en base a la experimentación y el análisis y transfiriendo el conocimiento a nuevas situaciones

Colaborar eficazmente en equipos de trabajo, asumiendo responsabilidades y funciones de liderazgo y contribuyendo a la mejora y desarrollo colectivo

Contribuir en el diseño, desarrollo y ejecución de soluciones que den respuesta a demandas sociales, teniendo en cuenta como referente los Objetivos de Desarrollo Sostenible

Demostrar razonamiento crítico y autocrítico en el ámbito de la titulación, considerando aspectos tales como la ética profesional, los valores morales y las implicaciones sociales de las diferentes actividades realizadas

Propose creative and innovative solutions to complex situations or problems, typical of the area of ¿¿¿¿connection, to donate responses to the various professional and social needs

Saber comunicarse de manera efectiva, tanto de forma oral como escrita, adaptándose a las características de la situación y de la audiencia

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.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	33,00
Classroom practices	12,00
Total hours	**45,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	4,00
Preparation of lessons	28,00
Preparation for assessment activities	35,50
Resolution of case studies	0,00
Total hours	**67,50**

TEACHING METHODOLOGY

The subject will be taught in the form of theoretical classes of one hour duration in the classroom. These classes will include not only the exposition of concepts, but also examples of application of these concepts to the resolution of biological problems. In parallel, other problems of biological interest will be presented periodically to be solved by the student. These will be based on the theoretical explanations received, the problems solved in class, and auxiliary bibliography that the professor may suggest. In the practical classes the solution to these problems will be discussed in detail with the active participation of the students.

The distribution of the teaching and the relation between in-class and online activities may be modified throughout the course if health or weather conditions so require.

EVALUATION

Since the course is based on a series of basic concepts that must be assimilated in order to continue progressing, a continuous evaluation will be carried out to encourage the student to keep the course up to date.

A continuous evaluation is proposed through short exams carried out with a periodicity of approximately four weeks. These exams will not eliminate material but will be accumulated throughout the course. Alternatively, for those who do not pass the continuous evaluation, there will be a final written exam of the whole course.

The exams will consist of both theoretical questions and problems (the latter can be solved in some cases with the help of notes and books). In both cases, not only the acquisition of knowledge but also the ability to apply it to model biological problems, analyze the models and their predictions, and draw relevant conclusions will be evaluated. The exams will be graded out of a total of 10 points, being necessary to achieve a grade of 5.0 (either as an average of the periodic exams or as a grade of the final exam) 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.
- SNEPPEN,K. Models of life: Dynamics and regulation in biological systems. Cambridge University Press, 2014
- VOIT, E. A first course in Systems Biology. Garland Science, 2012.

Additional references

- ALON, U. Systems Medicine: Physiological Circuits and the Dynamics of Disease. Chapman &

Hall/CRC, 2023.
- 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.
- SEGEL, L.A. y EDELSTEIN-KESHET, L. A primer on mathematical models in Biology. SIAM Press, 2013.
- Van den BERG, H. Mathematical models of biological Systems. Oxford University Press, 2011.