

**COURSE DATA****DATA SUBJECT**

**Code:** 33144  
**Name:** Molecular evolution and biochemistry  
**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	First quarter

**SUBJECT-MATTER**

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

**COORDINATION**

BARRIO ESPARDUCER ELADIO

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**SUMMARY**

**Molecular and Biochemical Evolution** is an optional course of 6 ECTS, which is taught at the end of the Degree in Biochemistry and Biomedical Sciences. This course, together with Bioinformatics and System Biology, is part of the "Quantitative and Systems Biology" subject, within the module on "Methods in molecular biosciences and biomedicine".

This course offers a panorama of biological evolution at the molecular level, from the origin of the life to the diversification of the extant cellular lineages. Firstly, we will analyze the main models for the origin of the biological systems. The development of new sequencing techniques allowed obtaining a wealth of information on genome structure, function, and variation. The aim of the present course is to familiarize students with the study of the dynamics of evolutionary change at the molecular level, the understanding of the mechanisms and processes involved in the generation of genome variation patterns, and, also, on how these patterns can be used to reconstruct the evolutionary history of organisms and their genomes. Also, the evolution of metabolic pathways and networks will be analyzed.

**PREVIOUS KNOWLEDGE****RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE**



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

## OTHER REQUIREMENTS

The course "Bioinformatics" is recommended, although not mandatory, because introduces the use of software for sequence alignment and phylogenetic reconstruction.

## COMPETENCES / LEARNING OUTCOMES

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Capacidad para la asimilación de textos científicos en inglés.

## DESCRIPTION OF CONTENTS

### 1. MOLECULAR AND GENOME EVOLUTION

**MODELS OF MOLECULAR EVOLUTION.** Dynamics of genes in populations. Models of the evolutionary process. Rates and patterns of nucleotide substitution. The neutral theory of molecular evolution. Molecular Clocks. The nearly neutral theory. The controversy between neutralism and selectionism.

**EVOLUTIONARY CHANGE IN NUCLEOTIDE AND AMINO ACID SEQUENCES.** Positional homology and nucleotide and amino acid alignments. Nucleotide substitution in a DNA sequence. The divergence between DNA sequences. Non-uniform rates among nucleotide sites. The divergence between coding sequences. The divergence between proteins.

**MOLECULAR PHYLOGENETICS.** Phylogenetic trees. Methods of phylogenetic reconstruction based on characters and distances. Statistical methods in phylogenetic reconstruction. Reliability of the phylogenetic reconstructions. Phylogenomics. Molecular phylogenetics: applications.

**DNA POLYMORPHISM IN POPULATIONS.** Measures of DNA polymorphism. Gene Genealogy and the coalescent theory. Detection of natural selection. Molecular genetics of populations and the origin of humankind.

**EVOLUTION OF GENOME COMPLEXITY.** Variation in genome size. The repetitive structure of the eukaryotic genome. Evolution of gene function. Evolution of gene redundancy. Formation of new genes. The origins of genome complexity

### 2. BIOCHEMICAL, CELLULAR AND METABOLIC EVOLUTION

**ORIGIN OF LIFE.** Definition of life and origin of life. Formation of the Earth. Simulation experiments in prebiotic chemistry. The emergence of the metabolism, cellularity, and molecular replicators. Protometabolic networks and canalization of energy. Lipid vesicles as protocellular models. Theories of the origin of genetic information and experimental models of RNA evolution.

**THE RNA WORLD.** The hypothesis of the RNA world. Precursors and descendants of RNA: the origin of proteins and DNA. Origin and evolution of the genetic code.



**ORIGIN AND EVOLUTION OF PROKARYOTIC LIFE.** Chemical and paleontological evidence of the first life forms. Reconstructing the universal common ancestor: phylogenetic and genomic methods. Origin of major cell domains. Coevolution of life and the planet: effects of atmospheric oxygen on cell and metabolic complexity.

**ORIGIN AND EVOLUTION OF EUKARYOTIC LIFE.** Origin of the endomembrane systems. Symbiotic models for the origin of energetic organelles. Origin of the cell nucleus. Genome acquisition by symbiosis and evolution of complexity.

**EVOLUTION OF METABOLISM.** Enzymatic properties and evolvability. Models of metabolic pathway and network evolution. Biomedical aspects of metabolic evolution.

**EXPERIMENTAL EVOLUTION.** Directed molecular evolution: methodology and examples. Applications of directed evolution in synthetic biology. Adaptative laboratory evolution: methodology and applications.

## WORKLOAD

### PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	4,00
Theory	56,00
<b>Total hours</b>	<b>60,00</b>

### NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	5,00
Individual or group project	13,00
Independent study and work	50,00
Preparation of lessons	14,00
Preparation for assessment activities	5,00
Resolution of case studies	3,00
<b>Total hours</b>	<b>90,00</b>

## TEACHING METHODOLOGY

The course is based on the use of different learning methods including:

**Lectures.** The professor will introduce, in sessions of 1 hour, the fundamental concepts of each topic, using appropriate audiovisual resources, which will be accessible to students through the platform for teaching support (virtual classroom). During these sessions, students will also focus on appropriate literature and resources to study and understand the key concepts. These concepts will be reinforced by attending conferences and seminars as part of the course.

**Seminars and other related activities.** Students will prepare short oral scientific communications of 30 min, including questions. These activities will be conducted in sessions of 2 hours.

The total number of hours of class in full group (theory classes, seminars, and other activities) will be 52 hours.

**Small group tutorial sessions.** These tutorials will be used to discuss papers read by students, or current issues



related to the subject, as part of the continuous evaluation of students. Students should prepare and pose questions during the course, which may be answered by other students or the professor. The activity will be held in 4 sessions of 1 hour each.

**Individual tutorials.** These personal interviews will be used to solve specific questions or personal problems related to the course. E-mail may be also used for this purpose.

## EVALUATION

An ongoing assessment of the achievements of each student will be performed on the basis of the different activities described in the Methodology section, such as attendance, the completion, and submission of all homework and the active participation and the degree of involvement in the learning process. The specific aspects to be evaluated are:

- **An objective test of the contents of the course.** It consists of an exam of theoretical questions, either in the form of short, long, or multiple-choice questions. This exam will focus on the understanding of basic concepts for the development of their knowledge and skills to achieve the main goals of the course. This exam will represent 60% of the final score, but it is mandatory to pass this exam with a minimum score of 5 out of 10, provided that it has been scored in both thematic blocks above 40% of its value.
- **Evaluation of scientific communications during seminar sessions.** The evaluation of this activity will test the ability of the student to obtain scientific information and to provide criteria for assessing its validity, the capacity to disseminate scientific knowledge, the ability to deal with teamwork and the ability to present their results. This activity will represent 25% of the final score.
- **Assessment of participation in classroom activities, group tutorials, and other activities.** Among other things, this section will evaluate the ability to ask questions, propose answers and lead the group discussion, as part of the evaluation of the student. This section will contribute 15% of the final score.

## REFERENCES

### Basic References:

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Lynch, M. (2007) *The origins of genome architecture*. Sinauer.

Nei, M. and Kumar, S. (2000) *Molecular Evolution and Phylogenetics*. Oxford Univ Press.

### **Complementary References:**

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Bromham, L. (2008) *Reading the Story in DNA: A Beginner's Guide to Molecular Evolution*. Oxford Univ. Press.

Brown, T.A. (2007) *Genomes 3*. Oxford. (Versió en castellà: *Genomas*. Editorial Médica Panamericana).

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Luisi, P.L. (2006) The Emergence of Life. From Chemical Origins to Synthetic Biology. Cambridge University Press, Cambridge.

Oparin, A.I., Haldane, J.B.S. (2007) L'origen de la vida. Publicacions de la Universitat de València.

Patthy, L. (2007) Protein Evolution, 2nd Ed. Blackwell Science.

Yarus, M. (2010) Life from an RNA World. The Ancestor Within. Harvard University Press, Cambridge.