COURSE DATA

Data Subject	
Code	33144
Name	Molecular evolution and biochemistry
Cycle	Grade
ECTS Credits	6.0
Academic year	2023 - 2024

Study (s)

Degree	Center	Acad. year	Period
1109 - Degree in Biochemistry and Biomedical Sciences	Faculty of Biological Sciences	4	First term

Subject-matter

Degree	Subject-matter	Character
1109 - Degree in Biochemistry and Biomedical Sciences	14 - Materia de asignaturas optativas	Optional

Coordination

Name	Department
BARRIO ESPARDUCER, ELADIO	194 - Genetics
GARCIA FERRIS, CARLOS	30 - Biochemistry and Molecular Biology
PERETO MAGRANER, JULI	30 - Biochemistry and Molecular Biology

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 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.

OUTCOMES

1101 - Degree in Biochemistry and Biomedical Sciences

- Have capacity for analysis, synthesis and critical reasoning in the application of the scientific method.
- Desarrollo de habilidades para la aplicación de los conocimientos adquiridos al mundo profesional.
- Understand the natural world as a product of evolution and its vulnerability to human influence.
- Be able to use new information and communication technologies.
- Know how to use the different bibliographic sources and biological databases and be able to use bioinformatic tools.
- Know the usual procedures used by scientists in the area of molecular biosciences and biomedicine to generate, transmit and disseminate scientific information.
- Know the common and differential molecular and cellular elements of the different types of living organisms with special emphasis on the human being and model organisms for their study.
- Understand experimental approaches and their limitations and interpret scientific results in molecular biosciences and biomedicine.
- Know how to design multidisciplinary experimental strategies in the field of molecular biosciences to solve complex biological problems, especially those related to human health.
- Acquire skills to use the methodologies of molecular biosciences and to keep an annotated record of activities.
- Know how to use mathematical and statistical tools to solve biological problems.
- Know the chemical and physical principles that determine the properties of biological molecules and govern the reactions in which they are involved.
- Recognise biological diversity and know the organisation of living beings and the position of human beings and model organisms in biomedical experimentation amid this diversity.

- Know the structural and functional characteristics of macromolecules.
- Know the biochemical and molecular bases of cell function.
- Know and understand the molecular bases of genetic information and the mechanisms of its transmission and variation.
- Have an integrated view of normal and altered cell function, including metabolism and gene expression.
- Conocer las teorías que describen y explican la complejidad de los sistemas celulares.
- Conocer los principios físicos que subyacen en la complejidad metabólica, su dinámica y control, y su relación con la patología y la biotecnología.
- Conocer los métodos que permiten manejar grandes cantidades de datos derivados de las técnicas ómicas.
- Conocer los mecanismos evolutivos a escala molecular.
- Conocer las principales transiciones evolutivas y su ubicación en la escala de tiempo.
- Saber utilizar los principales métodos bioinformáticos.
- Acceder a las principales bases de datos biológicos y recuperar y emplear la información contenida en ellas.
- Aplicar correctamente los métodos de inferencia filogenética e interpretar los resultados.
- Analizar críticamente las definiciones de vida, sus implicaciones teóricas y sus aplicaciones en biología de sistemas y biología sintética.
- Conocer los mecanismos de generación de diversidad enzimática y los modelos de evolución metabólica.
- Conocer la simbiosis como mecanismo de generación de complejidad genómica, metabólica y celular.

LEARNING OUTCOMES

- Understand the cellular physiology from an evolutionary perspective.
- Perform multiple sequence alignments.
- Obtaining and interpreting phylogenetic trees.
- Obtain better knowledge and respect for human diversity.
- Teamwork abilities.
- Analyze the different approaches to solve complex scientific problems.
- Capacity for analysis, synthesis and critical thinking.
- Proper use of scientific English.
- The ability for written and oral transmission of scientific results.
- Critical analysis of scientific information.
- Analysis of the relationships between science and society.
- Analysis of cultural values implicit in the knowledge and practice of science.
- Dealing with the historical dimension of science.
- Assimilation of the construction process of science.
- Analysis of ethical dilemmas arising from the application of molecular biosciences and their impact

into Society.
- Locate molecular biosciences and biomedicine in the context of science through the knowledge of some of the major issues in today's world.

DESCRIPTION OF CONTENTS

1. Chemical evolution and origin of life

WHAT IS LIFE? The problem of the living definition. Self-organization, autopoiesis, autonomy and open evolution. Recursivity. The problem of the measure of the complexity.
CHEMICAL EVOLUTION. Formation of the planet and abiotic chemistry. Contribution of extraterrestrial materials and the endogenous organic syntheses. Experiments of simulation in prebiotic chemistry.
ORIGIN OF LIFE. The emergence of the metabolism, cellularity and molecular replicators. Protometabolic networks and canalization of energy. Lipid vesicles as a protocellular models. Theories of the origin of genetic information and experimental models of RNA evolution.
ORIGIN OF TRANSLATION AND THE GENETIC CODE. The hypothesis of the RNA world. Precursors and descendants of RNA: origin of proteins and DNA. Origin and evolution of the genetic code.

2. 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.

3. Cell and metabolic evolution

ORIGIN 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 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. Experimental evolution. Enzymatic properties and evolvability. Models of metabolic pathway and network evolution. Biomedical aspects of metabolic evolution.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	56,00	100
Tutorials	4,00	100
Attendance at events and external activities	5,00	0
Development of individual work	13,00	0
Study and independent work	40,00	0
Readings supplementary material	10,00	0
Preparation of evaluation activities	5,00	0
Preparing lectures	10,00	0
Preparation of practical classes and problem	4,00	0
Resolution of case studies	3,00	0
TOTAL	**150,00**	

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 maybe 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 issues. 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, and has scored in all thematic blocks (I, II and III) 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

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- Gargaud, M. et al. (eds) (2011) Encyclopedia of Astrobiology, 3 Vols. Springer

Additional

- Deamer, D. (2011) First Life. Discovering Connexions Between Stars, Cells, and How Life Began. California University Press.
- Avise. J. (2004) Molecular Markers, Natural History and Evolution 2nd ed. Chapman & Hall.
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