Universitat Autònoma de Barcelona

2019/2020

Molecular Biology

Code: 102523
ECTS Credits: 6

Degree	Type	Year	Semester
2501922 Nanoscience and Nanotechnology	OB	2	2
2502444 Chemistry	OT	4	0

Contact

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Use of Languages

Principal working language: spanish (spa)
Some groups entirely in English: No
Some groups entirely in Catalan: No
Some groups entirely in Spanish: Yes

Teachers

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Prerequisites

Ther are no pre-requisits to attend this course.

Objectives and Contextualisation

This subject integrates the description of the molecular mechanisms that occur in the processes of transmission of genetic information (replication, transcription and translation) with its technical applications.

Specific objectives:

- To know the different structures that adopt the nucleic acids, as well as the different degrees of packaging of the DNA according to the type of organism and the moment of the cell cycle.

- To know the mechanisms of replication, recombination, and DNA repair that maintain the integrity of genetic information; as well as the epigenetic modifications that are transmitted between generations.

- Understand the function of the different RNA polymerases and the mechanisms for controlling the transcription according to the type of organism.

- To know the structure and function of the ribosomes, the differences between prokaryotes and eukaryotes, and the mechanisms for controlling translation.

- Introduce the recombinant DNA tools and their applications.

- Introduce the genomic tools that allow a global approach to the study of the different processes of transmission of genetic information.

Competences

Nanoscience and Nanotechnology

- Adapt to new situations.
- Apply the concepts, principles, theories and fundamental facts of nanoscience and nanotechnology to solve problems of a quantitative or qualitative nature in the field of nanoscience and nanotechnology.
- Apply the general standards for safety and operations in a laboratory and the specific regulations for the use of chemical and biological instruments, products and materials in consideration of their properties and the risks.
- Be ethically committed.
- Communicate orally and in writing in ones own language.
- Demonstrate knowledge of the concepts, principles, theories and fundamental facts related with nanoscience and nanotechnology.
- Handle the standard instruments and materials of physical, chemical and biological testing laboratories for the study and analysis of phenomena on a nanoscale.
- Interpret the data obtained by means of experimental measures, including the use of computer tools, identify and understand their meanings in relation to appropriate chemical, physical or biological theories.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
- Operate with a certain degree of autonomy.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise the terms used in the fields of physics, chemistry, biology, nanoscience and nanotechnology in the English language and use English effectively in writing and orally in all areas of work.
- Resolve problems and make decisions.
- Show motivation for quality.
- Show sensitivity for environmental issues.
- Work correctly with the formulas, chemical equations and magnitudes used in chemistry.
- Work on the synthesis, characterisation and study of the properties of materials on a nanoscale from previously established procedures.

Chemistry

- Adapt to new situations.
- Apply knowledge of chemistry to problem solving of a quantitative or qualitative nature in familiar and professional fields.
- Communicate orally and in writing in ones own language.
- Handle chemical products safely.
- Handle standard instruments and material in analytic and synthetic chemical laboratories.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Manage, analyse and synthesise information.
- Obtain information, including by digital means.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise and analyse chemical problems and propose suitable answers or studies to resolve them.
- Resolve problems and make decisions.
- Show an understanding of the basic concepts, principles, theories and facts of the different areas of chemistry.
- Show sensitivity for environmental issues.
- Work in a team and show concern for interpersonal relations at work.

Learning Outcomes

1. Adapt to new situations.

2. Apply the basic methods of recombinant DNA technology.
3. Be ethically committed.
4. Communicate orally and in writing in ones own language.
5. Correctly handle the separation and analysis equipment used in biochemistry and molecular biology laboratories.
6. Correctly use the laboratory material, microorganisms and cells used in biology laboratories.
7. Correctly use the necessary computer tools to interpret and expose the results obtained.
8. Describe the basic methodologies of recombinant DNA technology for application to the expression of recombinant proteins.
9. Describe the differential regulation of gene expression in prokaryotes and eukaryotes.
10. Describe the fundamental properties of nucleic acids.
11. Describe the molecular mechanisms involved in the perpetuation, maintenance and generation of variability in genetic information.
12. Describe the strategies used for modifying the genome of different organisms.
13. Describe the structural models of DNA folding in chromosomes.
14. Describe the structure and topological properties of DNA, and the structure-function ratio of nucleic acids.
15. Design and execute the amplification, cloning and molecular hybridisation of a cDNA from mRNA.
16. Evaluate how dangerous biological samples and reagents are in a specific framework.
17. Evaluate the danger and risks of the use of samples and reagents, and apply suitable safety precautions for each case.
18. Explain the molecular mechanisms of the transmission of genetic information from nucleic acids to proteins.
19. Identify and distinguish the protocols for using complex equipment for characterisation, analysis and manipulation of biomolecules and cells.
20. Identify and situate safety equipment in the laboratory.
21. Identify the mechanisms that regulate the vital functions of living beings.
22. Identify the risks associated with the handling of biological samples and reagents.
23. Interpret analytical results and their quality.
24. Interpret the results obtained from genetic and protein engineering techniques.
25. Interpret the results obtained in biology laboratories on microbiology and animal cell cultures.
26. Justify the results obtained in the laboratory from biomolecule separation, purification and characterisation processes on the basis of knowledge on their structure and properties.
27. Learn autonomously.
28. Manage the organisation and planning of tasks.
29. Manage, analyse and synthesise information.
30. Obtain information, including by digital means.
31. Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
32. Operate with a certain degree of autonomy.
33. Perform basic genetic engineering and protein engineering procedures.
34. Propose creative ideas and solutions.
35. Propose strategies to obtain mutants of a recombinant protein and for the purification of the same.
36. Reason in a critical manner
37. Recognise recombinant DNA and large scale analysis techniques.
38. Recognise the English terms employed in biochemistry, molecular biology, microbiology, immunology and in subjects related with nanoscience and nanotechnology.
39. Resolve bioanalysis problems based on enzymes, antibodies and DNA as an analyte or element of biorecognition in the environmental, clinical and food fields.
40. Resolve problems and make decisions.
41. Safely handle chemical and biochemical reagents.
42. Safely handle microorganisms and animal cells.
43. Safely manipulate chemical reagents and organic compounds.
44. Safely use laboratory instruments used in biochemistry, microbiology, cell cultures and bioanalysis.
45. Show motivation for quality.
46. Show sensitivity for environmental issues.
47. Understand texts and bibliographies in English on biochemistry, molecular biology, microbiology, immunology and in subjects related with nanoscience and nanotechnology.

48. Use knowledge of molecular biology to understand and interpret large scale sequencing techniques.
49. Use suitable strategies to handle and eliminate certain biological materials.
50. Use the suitable strategies for the safe elimination of reagents, microorganisms, cells and nanomaterials.
51. Work correctly with the formulas, chemical equations and magnitudes used in chemistry.
52. Work experimentally with biological material (inert, aseptic and/or controlled atmospheres).
53. Work in a team and show concern for interpersonal relations at work.

Content

THEORY

1. INTRODUCTION: NUCLEIC ACIDS. STRUCTURAL LEVELS.

Chemical structure and composition. Chemical properties of DNA and modifications. Topology Structural levels of eukaryotic chromatin.

2. REPLICATION

Replication types. DNA polymerases I and III. Helicases, binding proteins, ligases and primases. Start and termination of replication in E. coli. Eukaryotic DNA polymerases. Telomeres and telomerases. Reverse transcriptase and retrotransposition.

3. DNA RECOMBINATION AND REPAIR

Point mutations. Mechanisms of DNA repair. Defective repair systems and cancer. DNA recombination. Homologous recombination. Site-specific recombination. Transposition. Other genetic rearrangements.

4. TRANSCRIPTION

Three-dimensional structure of prokaryotic RNA polymerase and promoter binding. Initiation, elongation and termination of transcription. Nuclear RNA polymerases and transcription control: Promoters type I and III. Promoters type II: transcription factors, response elements, enhancers and mediator. Processing of pre-mRNA: cap addition, polyadenylation, splicing and editing. Processing of other RNAs.

5. REGULATION OF EXPRESSION

Generalities. Regulation of gene expression in prokaryotes. Lac operon and trp operon. Regulation of gene expression in eukaryotes.

6. TRANSLATION

Nature of the genetic code. Aminoacyl tRNA synthetases. Structure of the ribosome. Peptide synthesis: initiation, elongation and termination. Control of translation in eukaryotes: Inhibition / potentiation of translation initiation. RNA interference and gene silencing.

7. MODIFICATION OF NUCLEIC ACIDS IN VITRO

Bacterial modification-restriction systems. Restriction enzymes. Isoschizomers. Analysis of digestions and restriction maps. Other enzymes that modify DNA.

8. CLONING TECHNIQUES

Gene manipulation: cloning and selection. Cloning vectors. Genomic libraries.

9. Polymerase chain reaction (PCR)

Generalities Design and optimization of the reaction. RT-PCR. Quantitative PCR.

10. Hybridization techniques

Generalities Hybridization techniques with and without electrophoretic separation.

11. Protein engineering.

Production of recombinant proteins. Directed mutagenesis. Genome editing with CRISPR/CAS.

12. GENOMICS

Sequencing techniques. DNA fingerprinting. High-Throughput genomic techniques.

PROBLEMS

The content of this section consists of a certain amount of problems related to the topics developed in the magistral lectures.

LABORATORY SESSIONS

The objective of the laboratory sessions is to perform the most frequent techniques in the Molecular Biology laboratory and its application: (i) Use of the PCR technique for the analysis of polymorphisms of biomedical / forensic interest; (ii) Phenotypic and genotypic identification of a plasmid.

The laboratory sessions are organized according to the following calendar:

Session	Analysis of human polymorfisms by PCR	Identification of a plasmid by genotype and phenotype
1	Extraction of genomic DNA Amplification of CCR5 gene by PCR	Transformation of plasmid DNA in E.coli Plate on selective media
2	Electrophoresis	Analysis of the transformed colonies Purification of plasmid DNA Digestion with restriction enzymes
3	Analysis of the results	Electrophoresis Espectrophotometric analysis of DNA Analysis ofthe results

Methodology

TEACHING METHODOLOGY AND FORMATIVE ACTIVITIES

The formative activities consist of classes of theory, problems and laboratory sessions. Each of them has its own specific methodology.

Theory classes

The teacher will explain the contents of the syllabus with the support of audiovisual material that will be available to students in the Virtual Campus of the subject, in advance. These lectures will be the most important part of the theory section. It is recommended that students have the material published on the CV in printed form in order to be able to follow the classes more comfortably. Under the guidance of the teacher, the knowledge of some parts of the syllabus will have to be deepened by the students, by means of autonomous learning. In order to facilitate this task, information about locations will be provided in textbooks, web pages, etc.

Problem classes

There will be 8 sessions of problems per group, in the data announced in the calendar. For these sessions, the theory group will be divided into two subgroups of the same size, whose lists will be made public at the beginning of the course. Students will attend the sessions programmed by their group.

At the beginning of the semester a document with a list of the problems of the subject will be delivered through the Virtual Campus that will be resolved throughout the sessions. In a limited number of sessions distributed throughout the semester, problem professors will present the experimental and calculation principles necessary to work on the problems, explaining the guidelines for their resolution, and at the same time giving a part of the complementary subject to the theory classes

Students will solve the problems in and outside class hours. Non-expositive classroom sessions will be devoted to the resolution of problems. At the end of each block of contents, the students grouped in pairs will solve and deliver of a new problem proposed by the teacher. The problemscan be solved and delivered in class as well as by the Moodle classroom when indicated by the professor.

Laboratory sessions

The attendance to the practices of this subject is obligatory, since they imply an acquisition of specific competences.

There will be 3 sessions of laboratory practices per group, in the data announced in the calendar. The students carry out the experimental work in pairs and under the supervision of the responsible professor. Laboratory protocols will be available in the Virtual Campus of the subject. Before beginning each practical session the student must have read the protocol and know therefore, the objectives of the practice, the background and the procedures that must be carried out. It is the student's obligation to know the specific laboratory safety and waste treatment measures.

In the practical sessions each student should have:

- A laboratory protocol.

- A notebook to collect the information of the experimental work.

- A laboratory coat.

- Safety glasses.

- Permanent marker.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Laboratory sessions	15	0.6	1, 2, 27, 4, 45, 33, 28, 29, 22, 19, 20, 23, 25, 24, 26, 5, 42, 41, 43, 3, 46, 32, 34, 36, 53, 52, 6, 7, 44, 50, 49, 16, 17
Lectures	30	1.2	47, 4, 11, 13, 14, 9, 12, 8, 10, 15, 18, 21, 36, 38, 37, 48
Problem sessions	8	0.32	1, 27, 4, 13, 8, 15, 28, 29, 24, 3, 32, 35, 34, 36, 37, 39, 40, 51, 53
Problem solving	18	0.72	2, 10, 15, 21, 37
Type: Autonomous			
Self-learning	27	1.08	11, 13, 14, 9, 8, 10, 18, 21, 35, 37
Study	48	1.92	11, 13, 14, 9, 12, 8, 10, 18, 21, 35, 38, 37, 39, 48

Assessment

General considerations:

- To pass the subject, the student must obtain a global grade equal to or greater than 5 points out of 10, and the minimum grade of 4 in the theory two partial tests. If in any of these tests the qualification is less than 4, the maximum global score will be 4 points out of 10.

- To be eligible for the retake process, the student should have been previously evaluated in a set of activities equaling at least two thirds of the final score of the course or module. Thus, the student will be graded as "No Avaluable" if the weighthing of all conducted evaluation activities is less than 67% of the final score

Theory

The contents of the lectures will be assessed through a continuous assessment consisting of two partial tests, each corresponding to approximately one half of the theoretical syllabus. Each assessment test will consist of answering a questionnaire with test questions.

(*) TO PASS THE SUBJECT IT IS IMPRESCINDIBLE THAT THEORY GRADE IN BOTH PARTIAL TEST WILL BE AT LEAST 40% OF THE MAXIMUM GRADE.

Those students who have not passed 40% of one or both partial tests (theory) must complete a retake exam of the corresponding partial/s. The final test will also be open to any student who, despite having passed the continuous assessment, wishes to improve the grade obtained; In this case however, the partial previously obtained is annulled.

Problems

Group evaluation with an additional component of individual assessment:

- 50% of the problem grade will correspond to the deliveries in pairs, of problems proposed by the professor.

- 50% of the problem grade will correspond to a maturity test (individual), where one or two problems, previously untreated in class. The maturity test will be solved and that will be performed on the date fixed for the examination of the second partial examination of theory.

The weight of the evaluation of problems will be 20% of the total of the subject. The grade obtained in the maturity test can be improved on the day of the final exam of the subject, taking into account that the previously obtained note is canceled.

Laboratory sessions

The laboratory sessions will be evaluated with an exam during the last session. The exam includes the treated contents and the analysis of results. The weight of the laboratory evaluation will be 15% of the total of the subject.

The final grade obtained will be calculated as follows:

a) Due partial theory tests: 6.5 points (Average of both partial, ordinary or recovery, if it exceeds 40% of the mark in each partial).

b) Problems: 1.0 point group assessment + 1.0 point maturity examination

c) Laboratory practices: 1.5 points Examination.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Laboratory sessions	1.5	0	0	1, 2, 27, 4, 45, 8, 15, 33, 28, 29, 22, 19, 20, 23, 25, 24, 26, 5, 42, 41, 43, 3, 46, 32, 34, 36, 40, 51, 53, 52, 6, 7, 44, 50, 49, 16, 17
Problems	2	2	0.08	1, 27, 4, 45, 13, 14, 8, 10, 15, 28, 23, 24, 26, 3, 30, 31, 32, 35, 34, 36, 38, 37, 39, 40, 51, 53
Theory partial test 1	3.25	1	0.04	27, 47, 11, 13, 14, 9, 10, 18, 29, 21, 36, 38
Theory partial test 2	3.25	1	0.04	1, 27, 47, 9, 12, 8, 10, 28, 29, 24, 35, 36, 38, 37, 48

Bibliography

Reference textbooks:

Lewin's Genes X (2011)

Biochemistry (4erd Ed, 2011) D. Voet & J.G. Voet Ed. John Wiley & Son J.E. Krebs, E.S. Goldstein, S.T. Kilpatrick. Ed. Jones and Bartlett Learning

Recombinant DNA: Genes and Genomes. A Short Course. J.D. Watson, R.M. Myers, A.A. Caudy and J.A.Witkowski. 3rd ed. 2007. Ed. Freeman
Principles of Gene Manipulation and Genomics. S.B. Primrose and R.M. Twyman. 8th ed. 2016. Ed Blackwell
Molecular Biotechnology: Principles and Applications of Recombinant DNA. B.R. Glick, J. J. Pasternak and C.L. Patten 4th ed. 2010. Ed AMS