Universidad de Alcalá

COURSE SYLLABUS

MOLECULAR BIOLOGY

Degree in Health Biology
Universidad de Alcalá

Academic Year/2024/2025

3rd Year– 1st Semester

Aprobada en Junta de Facultad 24/05/2024

COURSE SYLLABUS

Name of the subject:	**MOLECULAR BIOLOGY**
Code:	**650032**
Degree:	**DEGREE IN HEALTH BIOLOGY**
Department Area of Knowledge:	**SYSTEMS BIOLOGY** **BIOCHEMISTRY AND MOLECULAR BIOLOGY**
Subject Type:	**OBLIGATORY**
ECTS credits:	**6**
Year and semester:	**3rd Year, 1st semester**
Lecturers/Professors:	Lilian Puebla Jiménez (Coordinadora)
Tutorial schedule:	**Monday to Thursday 15:00-16:00 (previous appointment)**
Language of instruction:	English

1. COURSE DESCRIPTION

Modern biology is based on an understanding of the molecules that make up living cells and the multiple interactions that are established between them. The increasing knowledge we have on the structure, function and development of different organisms allows us to recognize that all life processes exhibit remarkable similarities when analyzed from a molecular point of view. Molecular Biology focuses on the study of the macromolecules and reactions traditionally studied by biochemists and on how these molecules regulate cellular processes, with special emphasis on those related to gene expression. All the concepts of Molecular Biology are derived from experiments which are increasingly more complex as the quality of the experimental techniques used to carry them out increases. Thus, it is a constantly evolving area of knowledge. The present subject aims at illustrating the essential aspects of the current state of knowledge in this field and how this knowledge was achieved, with special emphasis on future perspectives.

The course is obligatory and is comprised of 6 ECTS credits (150 hours), distributed as follows: 5 theory credits and 1 lab credit.

Prerequisites and Recommendations

For a full understanding of this course, the student must have acquired the competencies corresponding to the subject Biochemistry.

2. COMPETENCIES

General competencies

1. To learn and value the fact that scientific knowledge is based on experimental work.
2. To develop critical thinking, the capacity for analysis, synthesis and problem-solving, as well as the capacity to postulate and verify hypotheses.
3. To learn how to use scientific literature and manage the information
4. To improve oral and written communication skills in order to be able to relate and present key concepts briefly and clearly.
5. To develop the capacity for teamwork and the ability for individual work.
6. To learn how to work according to the scientific method.
7. To appreciate the importance of the dynamism of science as well as the advance of scientific knowledge in this field.

Specific competencies

1. To know the primary, secondary and tertiary structures of nucleic acids

2. To know the processes that allow the maintenance and transfer of the information contained in DNA

3. To know the processes that allow the regulation of gene expression

4. To know the posttranslational processes that proteins undergo

5. To know the basic techniques in Molecular Biology research from both a theoretical and practical point of view.

3. COURSE CONTENT

Blocks of contents	Total number of classes, credits or hours
Unit 1. DNA structure, replication, recombination and repair. 1. Structure of nucleic acids. DNA-B structure. DNA denaturation and renaturation. Structure of single-stranded nucleic acids. Alternative helical structures. Other structures: cruciform structure and triple helices. Superwinding. Topoisomerases. 2. The chemistry of DNA synthesis. Direction of DNA replication. Replication origins. The DNA replication machinery. Continuous and discontinuous synthesis of the replication fork. Eukaryotic DNA replication. 3. Eukaryotic DNA recombination. Formation and resolution of heteroduplex DNA: molecules involved. Role of the molecular recombination machinery in DNA repair. Transposition.	6 h whole group 1 h small group
Unit 2. Synthesis and processing of messenger RNA. 4. Eukaryotic RNA polymerases. Sequences that determine the site of transcription initiation. Concept of promoter in eukaryotes. Enhancers. DNA binding domains of transcription factors.Transcription initiation by RNA polymerase II. Regulation of transcription elongation. Termination of transcription. Methods to locate promoter sequences. Techniques for locating binding sites of proteins to DNA: footprinting and electrophoretic mobility shift assay. 5. Molecular identity signals of the mRNAs and posttranscriptional processes that modify their sequence. The 5´-Cap. Cleavage and 3'-Poly(A). Splicing. Edition. 6. mRNA export from the nucleus to the cytoplasm. Involvement of the nuclear pore complex.	5 h whole group 2 h small group
Unit 3. Molecular translation machinery. 7. Transfer RNAs and aminoacyl-tRNA synthetases. Molecular characteristics of tRNA. Spatial structure. Modified bases. Metabolism of the 3'-CCA end. Aminoacyl-tRNA synthetases. Aminoacylation reaction of the tRNAs. Biological implications of the specificity of aminoacyl-tRNA synthetases. 8. Ribosome structure at high resolution The nucleolus. Ribosome assembly from ribosomal RNA precursors in prokaryotes and eukaryotes. The ribosome as a ribozyme.	3 h whole group 1 h small group

Unit 4. Translation of messenger RNA. 9, Steps in the translation process. Initiation in bacteria. Shine-Dalgarno sequence. Formil-methionil-tRNA. Initiation factors and initiation complex. Initiation in eukaryotes. Assembly of the initiation complex; components and factors involved. Kozak sequence. Cap-independent initiation. Elongation cycle. Peptidyl-transferase activity. Translation termination. Release factors. Polysomes and the closed loop model. 10. Alternative elongation-termination programmed by instructions in the mRNA. Redefinition of nonsense codons. Translational encoding of the aminoacid selenocysteine. +1 and -1 frameshifting. Ribosomal hopping. tmRNA and the salvage mechanism for rescuing bacterial ribosomes. 11. mRNA degradation coupled with the process of active translation. Pathway for poly(A) shortening and removal of the 5´cap. Elements that accelerate poly(A) shortening and removal of the 5´cap. Degradation initiated by specific endonucleases. Degradation of histone mRNA..Nonsense-mediated decay. Nonstop-mediated decay. 12. Cytoplasmic mechanisms of post-trancriptional control. Regulation by non-coding RNAs: microRNAs, siRNAs, piRNAs, tiRNAs, lncRNAs, circRNAs. Cytoplasmic polyadenylation promotes transcription of certain mRNAs. Surveillance mechanisms prevent the translation of incorrectly processed RNAs. Cytoplasmic mRNA localization. Global regulation of protein synthesis. Lab: Induction and analysis of proteins expressed in bacteria.	8h whole group 2 h small group 12 h labs
Unit 5. Posttranslational processes. Protein folding, modifications, sorting and degradation. 13. Protein folding. Chaperones and chaperonins. Protein sorting and localization in functional subcellular compartments. Concept of signal peptide. Endoplasmic reticulum-Golgi complex sorting pathway. Signal recognition particle, SRP. Topogenic sequences. Protein maturation. 14. Protein sorting in the cytoplasm. Plasma membrane-associated proteins: myristylation, prenylation and palmitoylation. Instructions for localization to different subcompartments of the plasma membrane. Nuclear proteins. Mitochondrial, chloroplast and peroxisomal proteins. 15. Protein degradation. The proteasome. Ubiquitin tags the cytosolic proteins for degradation. Other programmed degradation pathways.	6 h whole group 2 h small group

4. TEACHING-LEARNING METHODOLOGY

4.1. Distribution of credits (specify in hours)

Number of contact hours:	Classes big group: Classes small groups: Laboratory:	28 h 8 h 12 h
Number of hours of individual student work:	Individual study, work assignments, preparation for exams, online activities	102 h
Total number of hours:		150 h

4.2. Teaching methods, materials and resources.

Theoretical classes	Classes in which the professor teaches the basic knowledge of each topic, as well as the different methods used to attain that knowledge. On the other hand, diverse questions will be raised up in order to ponder on, discover and discuss the relationships between the different concepts that were taught in class.
Seminars and problem-solving classes	These seminars and problem-solving classes will be coordinated with the theoretical classes in order to manage, interrelate and apply the theoretical concepts and, thus, understand the theoretical principles associated to specific problems, extract the relevant information and learn how to use that information. In the seminars, we will approach, in a monographic manner, some specific aspects of topics covered in the course, in order to complete and reinforce concepts covered in the theoretical classes, or related topics of special interest. These topics will be prepared and presented orally by the students. The problem-solving classes will be organized to promote reasoning on

	concepts characteristic of the subject. These problems will be studied and resolved individually or in teams; the results will be presented orally in class and will be discussed with the rest of the group.
Practical classes	These classes will take place in the laboratory in small groups. With these classes, the knowledge acquired in the theoretical classes will be completed and practical skills to work in a molecular biology laboratory will be acquired. The students will be given a laboratory manual beforehand in which the theoretical basis of the lab and the procedure to be carried out is described. The students will carry out the lab under the supervision of the professor and will hand in the results, which will then be discussed.

5. EVALUATION: Procedures, evaluation and qualification criteria

According to the "regulations governing learning assessment processes" approved by the UAH Governing Council on March 24, 2011 and modified by the UAH Governing Council on July 22, 2021, in each academic year, the student has the right to two evaluation calls: an ordinary call and an extraordinary call.

Evaluation Procedure

Ordinary call.

It is based on a continuous evaluation, except in those cases contemplated in the UAH evaluation norm, in which the student has the right to a final evaluation procedure. In this case, the student must hand in a written request to the Dean or Director of the Center in the first two weeks of classes, explaining the reasons that do not allow him to follow the continuous evaluation system.

Continuous evaluation will be based on the collection of evidence by means of diverse strategies related to the teaching-learning process. The following will be evaluated: class attendance, student participation in the different classroom-based activities, student work in the seminars, the results of partial exams, an overall final exam and other activities.

The exceptional option of a final evaluation will consist of an exam covering all the course contents.

The evaluation of the skills and knowledge acquired during the **practical classes** will be carried out by means of experimental work, presentation of the results and an exam. Those students who have not carried out the labs cannot pass the course in this ordinary call.

Extraordinary call.

There will be an exam on the contents of the course, provided that the student has completed the practicals.

Evaluation criteria

- Understanding and assimilation of the contents
- Active participation, attitude and aptitudes demonstrated in the proposed activities.
- Capacity to apply the acquired knowledge.
- Interpretation of the results and question- as well as problem-solving.
- Argument of ideas and demonstration of critical thinking.

Qualification criteria

Ordinary call
In the **continous evaluation system**, the learning of each student will be evaluated by means of objective data obtained from:

- Laboratory work 10%
- Seminars 15%
- Two written exams 35%
- Overall final exam 40%

The exceptional option of a **final evaluation** will consist of a final exam that will account for 90% of the final grade. This exam will contain questions, problems and exercises that will allow the profesor to evaluate the acquisition by the student of the competencies described in the course syllabus.

Those students who did not perform the labs cannot pass the course in this ordinary call.

The ordinary call will be considered exhausted once the student has attended 50% of the course. Hence, those students who wish to appear as **not presented** must hand in a written communication to the Department secretary, before the last lecture class of November.

Extraordinary call
The exam will make up 90% of the total grade. This on-site test will consist of questions, problems and exercises to assess the student's acquisition of the competences set out in the teaching guide. The grade obtained in the practicals will account for 10% of the total grade.

During the assessment tests, the guidelines set out in the Regulation which establishes the *Norms of Coexistence of the Universidad de Alcalá* must be followed, as well as the possible implications of irregularities committed during these tests, including the consequences of committing academic fraud according to the *Student Disciplinary Regime Regulation of the Universidad de Alcalá*.

6. BIBLIOGRAPHY

Basic Bibliography

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- Herráez A. Texto ilustrado e interactivo de Biología Molecular e Ingeniería Genética, 2ª edición. Elsevier. **2012**
- Lodish, Berk, Kaiser, Krieger, Bretscher, Ploegh, Amon, Scott. *Biología Celular y Molecular*, (séptima edición). Ed. Médica Panamericana. **2015**
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- Krebs, Goldstein, Kilpatrick. *Genes XII*. Jones & Bartlett Learning, **2018**.
- Watson, Baker, Bell, Gann, Levine, R Losick. Molecular Biology of the Gene. (7th edition). Pearson. **2013**.

Library tutorials

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