COURSE DATA

DATA SUBJECT

Code: 33175
Name: Molecular genetics
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	3	Second quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1111 - Grado en Biotecnología	Molecular biology	COMPULSORY

COORDINATION

GIL GARCIA ROSARIO

SUMMARY

Genetics is the discipline of Biology that studies the heredity and variation in living organisms. Molecular Genetics studies these processes from a chemical point of view. The focus of Molecular Genetics is the gene, its structure, organization and function.

After the identification of the chemical nature of the hereditary material in the forties of the past century, in successive stages, Molecular Genetics has been dedicated to the study of the mechanisms of the genes function and its regulation, the development of the techniques of recombinant DNA, the study of gene expression during the different stages of development and the study of the structure and composition of complete genomes. These advances have implied the interaction and interrelation of Molecular Genetics with other biological sciences, its diversification in different fields of research, and the emergence of new subdisciplines, like Genetic Engineering, Developmental Genetics and Genomics, among others.

The nature of the research and the important social repercussions of both the methods and the possible results cause a constant presence of Molecular Genetics in mass media, making it an object of debate in the most different forums. On the other hand, the power of the molecular methods and the success achieved by Genetics have also had a great impact in biological sciences, attracting towards Molecular Genetics experts from other areas like biotechnologists, medical doctors, physiologists, botanists, microbiologists, etc., with diverse mentalities, giving rise to different questions about the expression,

organization and variation of the genes.

Throughout this course, and in an attempt to complement without interferences the Genetics and Molecular Biology knowledge presented to the students in the corresponding subjects, we will focus on the study of the structure and organization of genomes throughout the evolutionary scale (virus, prokaryotes and eukaryotes; in this last case, considering both the nuclear and the organelles genomes), as well as the mechanisms involved in the dynamics and evolution of genomes. Finally, we will analyze the implication of the regulation of gene expression in the processes of differentiation and development.

and development.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

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

OTHER REQUIREMENTS

It is highly recommended to be enrolled or have passed the subject "Molecular Biology"

COMPETENCES / LEARNING OUTCOMES

-

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

Apply analytical, synthetic and critical thinking skills in the application of the scientific method.

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

Conocer la composición, formación y función de cada compartimento celular y de los diferentes tejidos

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

Entender los procesos de división celular, fecundación y formación de organismos multicelulares

Participate in multidisciplinary teams, engaging in teamwork and collaboration.

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

Understand cellular signalling processes.

Use English to write reports and to interpret information from protocols, manuals and databases.

Work in laboratories, including safety procedures, waste management and accurate activity logging.

DESCRIPTION OF CONTENTS

1. Basic concepts

Chemical nature and molecular structure of the genes. What is a genome. What is Genomics. Genome projects and their importance. Strategies used for sequencing and assembling complete genomes. Methods for the study of genome content: Structural and functional annotation. Comparative genomics. From genomes to cells: the transcriptome and the proteome. Metagenomics.

2. Molecular bases of genomes evolution

(I): Mutation and recombination. Effects of mutations: nature of the genetic code. Error-prone DNA repair: SOS response. Molecular mechanism of DNA recombination. Models to explain homologous recombination: Holliday model and Messelson-Radding modification; double-strand-break repair model. Proteins involved in the homologous recombination. Homologous recombination and repair of the DNA. Site-specific recombination.

(II): Transposition. General characteristics and classification of transposable elements. Replicative and conservative transposition: general mechanisms. Transposable elements in prokaryotes: insertion sequences, composite transposons. Transposable elements in eukaryotes: types and mechanisms. Genetic and evolutionary meaning of the transposable elements.

3. Genome organization in viruses

Basic features of viral genomes. Classification of viruses based on nucleic acid type. Some examples: DNA and RNA bacteriofags, DNA and RNA animal viruses. Viroids and satellite RNAs: general features. Origin and evolution of viruses.

4. Genome organization in prokaryotes

The concept of species in prokaryotes. Sequenced prokaryote genomes and their general characteristics. Properties of the genomes of bacteria and arquea. Length. Physical structure. Genetic organization. Introns in prokaryotes. Evolution of bacterial genomes. Impact of horizontal gene transfer. Minimal genome and Synthetic Biology. Bacterial consortia. A dynamic vision of the prokaryotic genome.

5. Genome organization in eukaryotes

(I): Introduction. Eukaryotes genome projects. Variation in genome length and the C-value paradox. Kinetics of reassociation and complexity of the genomes. Classification of repetitive DNA. Sequencing of model organisms. Some data from sequenced genomes of interest: Caernohabditis elegans, trans-splicing and operons; the human and the chimpanzee genomes; the Neanderthal genome.

(II): Gene families. Introduction. Gene and genome duplications. Classification of homologous genes. Origin of new genes: molecular mechanisms. Families of repeated genes: rRNA genes. Families of related genes: the globins superfamily. Evolution of gene families: Mechanisms of concerted evolution.

(III): Tandem Repeat Sequences. Classification. satellite DNA: characteristics, isolation and location; origin and evolution. Minisatellite DNA: characteristics; methods of identification; DNA fingerprinting: applications. Microsatellite DNA: characteristic, methods of identification, applications. Telomeric DNA: structure, mechanism of maintenance, telomers in Drosophila, possible origin of telomerase.

(IV): Transposable elements. Dynamics of the transposable elements in the genome. Transposition via DNA: Classification, examples and applications. Transposition via RNA: Classification and examples. Origin of the retroelements and evolutionary relationships. Effects of the transposable elements in the genomes.

6. Organelles genomes

Extranuclear inheritance. General characteristics of the organelles. From endosimbionts to organelles. Structure and function of the mitochondrial genome. Mitochondrial genetic code. Characteristic of the mitochondrial DNA in fungi, plants, protozoa and animal. Structure and function of the chloroplast genome.

7. Genetic bases of diferentiation and development

(I): Introduction. Protein profile. Totipotency, determination, differentiation and cell memory. Body plan. Embryonic territories during early development. Main decisions in the development of the embryo.

(II): Binary Decisions. Sex determination in Drosophila. Programmed cell death in Caenorhabditis elegans.

(III): Complex Decisions. Positional information: asymmetries, gradients and cellular communication. Maternal-effect genes: establishment of the polarity. Segmentation genes: compartmentalization. Homeotic genes: identity of the segments. Evolutionary conservation of the homeotic genes. Segmentation in vertebrates: somitogenesis. Influence of the environment on animal development.

(IV): Special cases of differentiation. Differentiation by DNA rearrangements: somatic recombination in the immune system. Control of cell cycle and genetic bases of cancer.

8. Epigenetics

Epigenetic alterations of the genome. Epigenetic and imprinting. Epigenetics and cancer. Epigenetics and behavior. Epigenetics and the environment.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	3,00
Theory	30,00
Laboratory	2,00
Classroom practices	10,00
Total hours	**45,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	2,00
Individual or group project	10,00
Independent study and work	43,00
Preparation of lessons	12,00
Preparation for assessment activities	0,00
Resolution of case studies	0,00
Total hours	**67,00**

TEACHING METHODOLOGY

Theoretical sessions:
In the face-to-face work section, a total of 24 sessions of theoretical classes are included, one-hour lectures. Prior to each lesson, students will have a script of the same, in which will include a brief explanatory text of the content of the theoretical session, all the significant graphic material to be presented and a section with the latest bibliographical contributions to the subject. This script will be included in the corresponding web page of the Virtual Classroom of the Universitat de València. In this way, it is intended that the student can prepare in advance the classes and can follow them with comfort, taking only the necessary notes for proper understanding.

Practical activities:
1. Laboratory work session. There will be a two-hour working session in the laboratory for the development of the practical "Study of mutations affecting the larval cuticle pattern of *Drosophila*", as an illustration of the segmentation process in this organism by means of the study of different mutants [see U. T. 7(III). Genetic analysis of development]. Attendance to this practical session will be compulsory and at the end of the session the students will have to answer a questionnaire that they will deliver to the professor for evaluation.

2. Classroom work sessions. Throughout the course, and in accordance with the development of the theoretical sessions, students will be proposed to participate in additional activities and debates on topics related to the subject studied. In these sessions, the active participation of the students in the discussion of the proposed topic will be encouraged and they will be assisted in the search for appropriate material for the achievement of the proposed objectives.

3. Critical analysis of scientific texts. To encourage the student's capacity for synthesis and analysis, and his ability to express himself in writing clearly, each student may voluntarily submit in writing a brief summary and a critical discussion of an article proposed by the professor, related to a topic of the program selected by the student. The deadline for the delivery of the corresponding report will be 5 days after the treatment of the corresponding topic in the theoretical sessions.

Attendance to seminars:
Attendance to seminars on topics related to Molecular Genetics that may present an additional interest for students, such as the social impact of the topic or the presentation of a scientific novelty of great resonance, will be promoted. These seminars could be given
by an expert in the subject, or else be prepared by small groups of students. In the latter case
case, they will be presented in class for half an hour, followed by a small debate
on the topic.
Attendance to seminars and discussion sessions will be compulsory when they are held within the teaching period corresponding to the subject, and voluntary in the case that seminars are proposed outside this timetable. At the end of the seminars, the student will be given a questionnaire that he/she can voluntarily submit within the following 10 days.

Tutorials:

The function of the tutorials is to help and guide the student in a personal way in all the problems that may arise when facing the study of the subject. They facilitate the exchange of opinions between the teacher and the student, in an effort to approach individualized teaching.
Information and communication technologies can also be used to enhance the
teacher-student interaction. Consultations sent by students through e-mail
will be accepted, setting up a distance tutoring. Since this is a form of written communication, the student is obliged to carry out his own analysis of his doubts and to learn to express himself clearly in writing.
In addition to the individual tutorials, this teaching guide proposes three sessions of group tutorials in which, at the proposal of the students, those issues that have not been sufficiently clarified during the regular sessions or those issues that have raised an additional debate that had no place in the regular sessions will be solved jointly.

EVALUATION

1. Evaluation of the knowledge acquired by means of a written test: 75%. In it the student will have to answer a series of short questions and practical issues that reach the whole of the contents developed in class. The grade of this test will represent one of the global grade. It will be an indispensable condition to pass the course, to obtain at least a score of 5 out of 10 in this test.

2. Evaluation of the use of the obligatory practical laboratory session, by means of the answer to a questionnaire: 5%.

3. Participation in theoretical sessions, classroom work sessions, tutorials, debates and seminars throughout the course: 5%.

4. The remaining 15% may be obtained voluntarily through participation in the various activities up to the maximum allowed, being the maximum grade for each section:
- Submission of questionnaires related to seminars and debates: 5%.
- Critical analysis of scientific texts: 10%.
- Elaboration and presentation of seminars and debates: 15%.

All activities will be processed through the Virtual Classroom. Detailed instructions and evaluation criteria for each activity can be found in the Resources folder. All documents related to the activities will be submitted through the application \\\\Tasks\\\\. The grades will appear in the card of each student.
To request the advance of call of the subject, the student must have previously done
the compulsory activities specified in this teaching guide.

REFERENCES

- Brown, T.A. (2007). Genomes 3 (3rd edition). Oxford. (Traducido al castellano en Editorial Medica Panamericana).
- Pierce, B. A. (2014). Genetics : A conceptual approach, 5th edition. W. H. Freeman and Co. (Traducido al castellano en 2016 por Editorial Médica Panamericana).
- Krebs, J.E., E.S. Goldstein and S.T. Kilpatrick (2014). Lewin's Genes XI. Jones and Barlett Publishers. (Genes IX está traducido al castellano en 2008 por McGrawHill Interamericana Editores).
- Hartl, D.L. y Jones, E.W. (2005). Genetics: Analysis of genes and genomes, 6th edition. Jones and Bartlett.
- Watson, J. et al. (2005). Biología Molecular del gen. 5ª edición. Editorial Médica Panamericana
- Clark, M. (2000). Comparative Genomics. Kluver Academic Publishers
- DOE Joint Genome Institut. Why sequence them? http://www.jgi.doe.gov/sequencing/why/index.html
- Fontdevila, A. y Moya, A. (2003). Evolución. Origen, adaptación y divergencia de las especies. Editorial Síntesis.
- Gilbert, S. F. (2006). Developmental Biology, 8th edition. Sinauer Associates Inc. Publishers. (Traducido al castellano en Editorial Medica Panamericana)

- Gregory, T. R. (2006). The evolution of the genome. Elsevier.

- Hartwell, L., Hood, L., Goldberg, M.L., Silver, M.L., Veres, R.C. y Reynolds, A. (2004). Genetics: from genes to genomes, 2nd edition. McGraw-Hill.

- Human Genome Project Information. http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml

- Lynch, M. 2007. The origins of genome architecture. Sinauer Associates Inc. Publishers.

- Klug, W. S. et al. (2012). Concepts of Genetics (10th edition). Pearson Education. (Traducido al castellano en 2013).

- Benito, C. y Espino F.J. (2013). Genética. Conceptos esenciales . Editorial Médica Panamericana.