Universidad de Alcalá

TEACHING GUIDE

SUBJECT EVOLUTIONARY GENETICS

Degree in Biología
Universidad de Alcalá

Academic Year 2022/2023

3rd Year– 1st Quarter

Aprobada en Junta de Facultad 30/05/2022

TEACHING GUIDE

Name of subject:	**EVOLUTIONARY GENETICS**
Code number:	**650036**
Degree course on which the subject is taught:	**DEGREE IN BIOLOGY**
Department and Area of Knowledge:	**BIOMEDICINE AND BIOTECHNOLOGY/ GENETICS**
Category:	**OPTIONAL**
ETCS Credits:	**6**
Year/period:	**THIRD/ FIRST QUARTER**
Teacher:	**Joaquín Royo Cárcamo**
Tutorial timetable:	**Upon request to establish date and time**
Language in which the subject is taught:	Spanish/English friendly. Teaching resources in Spanish and English

1. INTRODUCTION

Recent advances in sequencing and other molecular techniques are providing a large volume of information about genetic variability in living beings. In addition, increasing knowledge in the field of molecular biology allows a better understanding of the mechanisms linking the information stored in genomes with the activities and external features of organisms. Consequently, it seems more feasible than in the past answering questions like what changes have taken place in the geographical distribution or size of populations, assessing the importance of migration fluxes among them, identifying positions subjected to selective changes in the genome of a species, pondering the strength of those selective pressures, or why a particular population become a species. The goal of this subject is to give students a solid foundation to confront those questions. Therefore, the course starts describing the extent of genetic diversity in natural populations (genes and alleles of each gene), how those genetic polymorphisms originate (taking into account our knowledge on Molecular Biology) and how they will or won´t change along time in response to a number of processes. This “population genetics” became “speciation” when external factors arise that impede gene fluxes among populations, subsequent changes enforcing those barriers pile up, and they ultimately block it, more or less completely. The course will also cover the relationship between genetic changes and developmental processes (the field generally known as “Evo-Devo”) and the identification and analysis of the evolutionary changes taking place in the sequences of proteins and nucleic acids. During seminars, students will learn to extract the information on the structure and location of the several members of a gene family available in the genomic databases, compare their sequences using standard phylogenetic computer programs, and combine all the data to provide a plausible evolutionary history of the gene family.

Requirements and recommendations

It is highly recommended that the student has previously passed the subjects of Genetics and Biochemistry in the second year of the Biology degree, or their equivalents in other degrees.
Evolutionary Genetics makes an extensive use of mathematical and statistical methods. In this course, considerable efforts have been made to reduce their description, and they will barely be the subject of questions in the exams, but students interested in following a professional career in this subject are encouraged to deepen their knowledge on those methods. I hope the foundations provided along this course will help them in that future endeavour, but they should be aware that a solid mathematical knowledge is an inexcusable prerequisite for that goal.
Each student should carry a portable computer with Internet access in the seminars and lab sessions (in the lab sessions the computer should run Windows) and a computer will be strictly needed to compliment the individual report of the work done during the seminars.

2. SKILLS

Generic skills:

1. Understanding the importance of experimental work for the progress of scientific knowledge.
2. Encouraging critical thinking and capacity for analysis and synthesis.
3. Development of skills related to finding scientific information, their critical assessment and using it for independent learning.
4. Ability to present arguments on scientific and social topics based on relevant data previously gathered and interpreted.
5. Development of oral and written communication skills.

Specific skills:

1. A knowledge of the evolutionary mechanisms and models.
2. A knowledge of the different techniques used to detect and measure genetic variability.
3. Understanding that mutations are random and the molecular basis of that property.
4. Ability to calculate the allelic and genotypic frequencies for genes with several alleles in natural populations.
5. Be able to demonstrate if a given population is in equilibrium from the values of its phenotypic frequencies.

6. Discern the conditions for achieving an equilibrium of allelic and/or genotypic frequencies under the effects of the different selective pressures (mutation, migration, selection, drift and non-random mating).
7. A knowledge of the foundations of natural selection and the applications of artificial selection.
8. Understanding the factors determining the relative strengths of selection and drift acting on populations.
9. Understanding the basis of the study of the inheritance of quantitative characters, the parameters used for their description and the way they influence their evolution.
10. A knowledge of the mechanisms that have been proposed to explain speciation.
11. A knowledge of the mechanisms linking evolution and development of living beings and the field of Evo-Devo.
12. A knowledge of the techniques for studying changes in the sequences of proteins and nucleic acids and the interpretation of the resulting data.
13. Be able to apply the usual methods of molecular phylogenetics and recognize their problems and limitations.

3. CONTENTS

Content units	Total of classes, credits or hours

1.- Introduction and general concepts.
 	
2.- Mutation and genetic variation in populations. Their origin, detection and measure.
 	
3.- Mendelian genetics in populations: the Hardy-Weinberg equilibrium and its consequences.
 	
4.- Deviations from equilibrium: selection. Effects of dominance on selection.
 	
5.- Deviations from equilibrium: mutation. Mutation-selection balance.
 	
6.- Deviations from equilibrium: migration. Effects on divergence among populations.
 	
7.- Deviations from equilibrium: genetic drift. Effective size of a population.
	• 36 h
	  • 28 h. large group
	  • 8 h. smaller group

8.- Deviations from equilibrium: non-random mating and inbreeding. 9.- Evolution in several loci: linkage equilibrium and disequilibrium. Quantitative characters. 10.- From populations to species: speciation mechanisms. 11.- Development and evolution: the Evo-Devo concept. Animal and plant examples. 12.- Molecular evolution: evolutionary changes detection in protein and nucleic acid sequences.	

4. LABORATORY SESSIONS

Lab session 1 Drift	3 h.
Lab session 2 Selection	3 h.
Lab session 3 Effects of selección on one locus on other loci	2 h.
Lab session 4 Migration and divergence among populations	2 h.
Lab session 5 Mating types	2 h.

5. TEACHING-LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES

5.1. Credits distribution (indicate hours)

Number of on-site hours: 50	Lectures: 28 Seminars: 8 Laboratory: 12 Assessments: 2
Number of hours of student work: 100	Independent study, solving problems and analysis of data obtained during seminars, reading of two scientific papers: 100
Total hours: 150	

5.2. Methodological strategies, teaching materials and resources

Classes	1. Lectures to large groups. 2. Seminars for learning phylogenetic analysis methods based on data from the sequences and gene structure of the members of a gene family from several species. 3. Lab sessions to small groups.
Independent/self-study	1. Studying and understanding of the theoretical topics covered in class. Searching for bibliographic resources. 2. Solving questions and problems related to some of the topics covered in classes. 3. Reading and analysis of two scientific papers provided by the lecturer. 4. Analysis and discussion of the results obtained during the lab sessions. Hypothesis formulation.
Tutorials	1. Individual or in small groups.

Materials and didactic resources

Students will have access to a website, located in one of the "on line" resources available in the UAH, containing all the didactic materials for the lectures, seminars and lab sessions. Information about its address and contents will be provided at the start of the course.

6. ASSESSMENT: procedures, criteria and ranks

Two evaluation modes are available, continuous and non-continuous. In accordance with the Regulations of Apprenticeships (approved by the Governing Council of the University of Alcalá on March 24, 2011), as indicated in Article 10, students will have a period of two weeks from the start of the course to request in writing to the Dean of the Faculty their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient.

In both evaluation models, laboratory sessions are compulsory. Consequently, students failing to attend lab sessions will be deemed "Not presented".

Laboratory work will be assessed through individual tests during the lab sessions. The average score obtained will be up to 20% of the final mark of the course. Students attending the lab sessions, but failing to get a positive average assessment, should take a new exam on them in the ordinary and/or extraordinary call. A positive assessment of the laboratory work is strictly needed to pass the course.

Non-continuous evaluation model

The final exam may include theoretical and problem solving questions. The score obtained will be up to 80% of the final mark of the course. The score obtained from the lab sessions will be up to 20% of the final mark. However, for the average to be calculated the student should have passed (5.0 over 10) both parts (final examination and lab sessions).

Students in the non-continuous evaluation model failing to pass the subject in the ordinary call will have the right to attend a final exam in the extraordinary call. This exam may include theoretical and problem solving questions. The score obtained will be up to 80% of the final mark of the course and the score obtained from the lab sessions will be up to 20% of the final mark. However, for the average to be calculated the student should have passed (5.0 over 10) both parts (final examination and lab sessions).

Continuous evaluation model

It will include:

1. A final exam, up to 40% of the final mark. The exam may include theoretical and problem solving questions.
2. An individual written report of the results obtained during the seminars with their personal computers, up to 20% of the final mark. This report should be delivered on schedule.
3. Answering individual written questionnaires on two scientific papers provided by the lecturer at the beginning of the course. Both reports should be delivered on schedule and their average will count up to 20% of the final mark.
4. Attending the lab sessions and answering the individual tests on the laboratory work. Their average will count up to 20% of the final mark.

A student will be considered “Not Presented” when, included in the continuous evaluation model, have not participated in any of the activities described above.

Students in the continuous evaluation model failing to pass the subject in the ordinary call will have the right to attend a final exam in the extraordinary call. This exam may include theoretical and problem solving questions. The score obtained will be up to 80% of the final mark of the course and the score obtained from the lab sessions will be up to 20% of the final mark. However, for the average to be calculated the student should have passed (5.0 over 10) both parts (final examination and lab sessions).

Marking criteria

About the contents:

Understands and can explain the main concepts of the subject using the correct terminology.

Understands, analyses and solves the problems proposed through the course.

Understands the concepts and ideas behind the lab sessions and seminars and can present his results in an orderly and comprehensive manner.

Distinguishes between essential and accessory.

Develops ideas coherently.

About the oral and written expression:

Clarity and accuracy. Neatness in the external appearance of the written texts.

Can present a coherent series of arguments.

Correction in the use of verbal and written language, including orthography and grammar.

Scoring scale

In accordance with the R.D 1125/2003 the scores should follow a numerical scale with one decimal place and a qualitative definition:

0,0 - 4,9	SUSPENSO (SS) (FAIL)
5,0 - 6,9	APROBADO (AP) (PASS)
7,0 - 8,9	NOTABLE (NT) (GOOD)
9,0 - 10	SOBRESALIENTE (SB) (EXCELLENT)
9,0 - 10	MATRICULA DE HONOR. Limited to 5% (HONORS)

7. BIBLIOGRAPHY

The main texts will be:

1. Freeman S. y Herron J.C. (2002) “Análisis Evolutivo”. Ed. Prentice Hall (there is a more recent 5th English edition (2014) Ed. Pearson)
2. Sætre G.P. and Ravinet M. (2019) “Evolutionary Genetics: concepts, analysis, and practice”. Oxford University Press.

Support texts for some specific issues:

1. Barton N.H.; Briggs D.E.G.; Eisen J.A., Goldstein D.B. y Patel N.H. (2007) “Evolution”. CSHL Press.
2. Soler, M. (coordinador) (2002) “Evolución: la base de la biología”. Proyecto Sur.
3. Caballero A. (2017) “Genética cuantitativa”. Editorial Síntesis.
4. Hartl, DL. (1988) “A primer of population genetics”. Sinauer Publishers.
5. Carroll S.B.; Grenier J.K. y Weatherbee S.D. (2005) “From DNA to diversity. Molecular genetics and the evolution of animal design” Blackwell Publishing.

To deepen into mathematical topics in population genetics that are only superficially covered in this course:

1. Fontdevilla, A. y Moya, A. (1999) “Introducción a la genética de poblaciones”. Editorial Síntesis.
2. Felsenstein, J. (2016) “Theoretical evolutionary genetics” University of Washington (Seattle). It can be freely downloaded from http://evolution.gs.washington.edu/pgbook/pgbook.pdf and it will be also available in the website of the course.

You can get a very clear, general and accurate view of many topics related to evolution from any of the books by Richard Dawkins, particularly:

1. “The selfish gene”
2. “The blind watchmaker”
3. “Climbing mount improbable”
4. “Unweaving the rainbow”

Stephan Jay Gould also wrote many books about evolutionary topics that are very clear and useful, but I recommend reading Dawkins´s books first because they will give you solid useful foundations before confronting some, maybe slightly contentious, Gould´s proposals.

The University of Alcalá guarantees its students that, if the competent authorities prevented the total or partial presence of the teaching activity due to health requirements, the teaching plans would achieve their objectives through a methodology of teaching-learning and evaluation in online format, which would return to the face-to-face modality as soon as these impediments ceased.