Teaching Guide				
Identifying Data				2023/24
Subject (*)	Population Genetics and Evolution		Code	610G02021
Study programme	Grao en Bioloxía			
Descriptors				
Cycle	Period	Year	Type	Credits
Graduate	2nd four-month period	Third	Obligatory	6
Language	SpanishGalicianEnglish			
Teaching method	Face-to-face			
Prerequisites				
Department	Bioloxía			
Coordinador	Naveira Fachal, Horacio	E-mail	horacio.naveira.fachal@udc.es	
Lecturers	, Naveira Fachal, Horacio Vila Sanjurjo, Antón	E-mail	natalia.mallo@udc.es horacio.naveira.fachal@udc.es anton.vila@udc.es	
Web	campusvirtual.udc.gal/course/view.php?id=14087			
General description	Introductory course to population genetics and evolution, dealing with the forces that act on gene frequencies in populations, the interactions between genotypes and environment that shape phenotypes, and the patterns of evolution of populations and species.			

Study programme competences / results	
Code	Study programme competences / results
A7	Reconstruír as relacións filogenéticas entre unidades operacionales e pór a proba hipóteses evolutivas.
A12	Manipular material xenético, realizar análises xenéticas e levar a cabo asesoramento xenético.
A18	Levar a cabo estudos de produción e mellora animal e vexetal.
A21	Deseñar modelos de procesos biolóxicos.
A24	Xestionar, conservar e restaurar poboacións e ecosistemas.
A27	Dirixir, redactar e executar proxectos en Bioloxía.
B1	Aprender a aprender.
B2	Resolver problemas de forma efectiva.
B3	Aplicar un pensamento crítico, lóxico e creativo.
B4	Traballar de forma autónoma con iniciativa.
B5	Traballar en colaboración.
B6	Organizar e planificar o traballo.
B7	Comunicarse de maneira efectiva nunha contorna de traballo.

Learning outcomes			
Learning outcomes	Study programme competences / results		
Capacity to interpret and to analyze the biological problems, as well as the human nature itself, from an evolutionary perspective	A7 A12 A18 A21	B1 B2 B3 B4 B5 B6 B7	

Choice of the techniques and methods more adequate to tackle the study of a specific evolutionary problem	A7 A12 A18 A24	B1 B2 B3 B4 B5 B6 B7	
Use of the genetic information to manage, to preserve and to restore populations.	A7 A12 A18 A21 A24 A27	B1 B2 B3 B4 B5 B6 B7	

Contents	
Topic	**Sub-topic**
OVERVIEW OF EVOLUTIONARY BIOLOGY	Brief history of Evolutionary Biology. Population genetics. Molecular evolutionary genetics. Evolutionary biology of development (evo-devo). Evolutionary genomics. The National Center for Biotechnology Information (NCBI) databases. Genome browsers (NCBI, UCSC, Ensembl). International projects to sample human genomes (IGSR, varsome)
MACROEVOLUTION	Evolution above the species level. Timeline of life on earth. The three domains of life. Using phylogenies to reconstruct the deep past. Diversification of eukaryotes. The species concept in paleontology. Patterns of macroevolution. Mass extinctions. Differences among clades in species diversity. The evolution of complex biological structures through the fossil record.
THE BUILDING OF EVOLUTIONARY MODULES	Promiscuous proteins; molecular machines; modular evolution of proteins. Evolutionary tinkering. Biochemical construction kits. Adaptations, exaptations and spandrels. Evolution of developmental programs: recycling networks. Retrograde and intercalary evolution. Gene duplications. Recruitment. Horizontal transmission. Linkage groups. Randomization effect of recombination. Genetic coadaptation. Supergenes.
MOLECULAR PHYLOGENIES	Cladograms and phylograms. Coalescence theory. Monophyletic, paraphyletic and polyphyletic taxa. Gene trees and species trees. Methods of molecular phylogenetics. The human evolutionary tree.
THE ORIGINS OF SPECIES	Concepts of species. Main questions related to speciation. Intrinsic reproductive barriers of isolation. Speciation and fitness landscapes: the shifting-balance theory. Modes of speciation. Adaptive radiations. Magic traits. Evolution of hybrid genetic incompatibilities. General rules of speciation and evolutionary diversification. Phyletic and cladistic evolution in the fossil record.
QUANTITATIVE GENETICS	Continuous, discontinuous and threshold characters. Breeding value and genotypic value of a genotype. Environmental value. Environmental sensitivity of a genotype. Components of phenotypic variance. Heritability. Estimation of the minimum number of loci underlying a quantitative trait (QTL). Mapping of QTLs. Genome-wide association studies (GWAS).

CONSEQUENCES OF REPRODUCTIVE SYSTEMS AND TYPES OF MATING ON THE ORGANIZATION OF GENETIC VARIATION	Maintenance of genetic variation in populations with sexual reproduction and random mating: Hardy-Weinberg law (H-W); deviations from H-W expectations. Effects of asexual reproduction and non-random mating on genotype frequencies: parthenogenesis; self-fertilization; inbreeding and relatedness coefficients; regular systems of inbreeding; phenotypic assortative mating. Genetic admixture.
RANDOM GENETIC CHANGES IN POPULATIONS OF SMALL SIZE	Sampling of gametes and random walk of gene frequencies. Wright-Fisher model. Dispersion of gene frequencies among subpopulations. Rate of fixation within subpopulations and genomes. Effective population size. Founder effects and population bottlenecks. Wahlund effect.
MUTATION AND MIGRATION	Classes of mutations: nucleotide substitutions; insertions and deletions; duplications; chromosome rearrangements. Mutation rates. Change in gene frequency due to mutation. The fate of a single mutant. Models of mutation in molecular population genetics. Migration and gene flow. Change in gene frequency due to migration; the island model. Mutation and migration in finite populations.
EFFECTS OF NATURAL SELECTION ON PHENOTYPES AND GENE FREQUENCIES	Natural selection. Biological fitness. Types of selection. Selection on quantitative traits. Measuring multivariate selection. Selection on correlated characters. Case study: the genetic basis of adaptation to high altitude in humans. Good genes or bad genes? Haploid and diploid basic models of selection. Polymorphisms maintained by constant selection coefficients. Fitness estimation. Fitness landscapes.
POLYMORPHISMS MAINTAINED BY VARYING SELECTION COEFFICIENTS	Spatial and temporal fitness variation: coarse-grained and fine-grained environments. Endocyclic selection. Trade-offs between fitness components. Antagonistic pleiotropy. Frequency-dependent selection. Cooperation, altruism and kin-selection.
COMBINED ACTION OF SELECTION AND OTHER EVOLUTIONARY FORCES. VARYING SELECTION COEFFICIENTS	Mutation-selection balance. Genetic load of populations. The role of recombination: Muller's ratchet and the degeneration of Y chromosomes; Hill-Robertson effects. Evolution of sex chromosomes. Equilibrium between selection and gene flow; gene clines. Selection in finite populations: neutral, nearly-neutral and selected mutations.
ENGINES OF EVOLUTION	Red Queen dynamics. Interspecies antagonisms. Sexual conflicts. Sexual selection vs. natural selection. Parent-offspring conflicts. Intergenomic conflicts: cytoplasmic incompatibility. Intragenomic conflicts: selfish genetic elements.
THE EVOLUTION OF SEX DETERMINATION	What is meiotic sex? The costs and benefits of sex. The diversity of sexual cycles among eukaryotes. Molecular mechanisms of sex determination. Sex determination in angiosperms. Sex determination in animals. Self-incompatibility systems. Quantitative genetics of sex determination: genotypic versus environmental sex determination. Systems lacking differentiated sex chromosomes. Transitions among sex-determination systems.
THE NEUTRAL THEORY OF MOLECULAR EVOLUTION. MOLECULAR FOOTPRINTS OF NATURAL SELECTION	The neutral theory of molecular evolution. Molecular clocks. Models of DNA evolution. Limits of nucleotide divergence. Estimates of the number of nucleotide substitutions. Substitution rates. Pseudogenes. Direct effects of selection on nucleotide polymorphism and divergence. The importance of recombination: selective sweep and background selection. Selection and demographic history can leave similar footprints on DNA variation. Statistical tests.

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Introductory activities	B1 B4 B5 B6	1	0.5	1.5
Guest lecture / keynote speech	A7 A12 A18 A24 A27 B1 B2 B3 B4 B6	21	52.5	73.5
ICT practicals	A7 A21 B2 B4	14	14	28

Seminar	A7 A12 B1 B2 B3 B4 B5 B6 B7	7	24.5	31.5
Multiple-choice questions	A7 A18 B1 B2 B3 B4 B5 B6	1	10	11
Objective test	A7 A12 A18 A21 A24 B1 B2	3.5	0	3.5
Personalized attention		1	0	1
(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.				

Methodologies	
Methodologies	**Description**
Introductory activities	Teacher presents the teaching guide of the subject, clarifies doubts, and organises the students for the activities. Student takes notes, formulates doubts and questions.
Guest lecture / keynote speech	Teacher explains the theoretical foundations of the subject. Student observes, assimilates and takes notes, formulates doubts and questions, memorises, reads the recommended texts, and solves complementary exercises.
ICT practicals	Teacher presents the objectives, prepares the material and equipment, explains the methods, provides a script, assists the students, and carries out an assessment of the activity. Student experiments with bioinformatics tools, analyses data and prepares a report.
Seminar	Teacher presents the topic from a historical perspective, distributes students into working groups, and carries out an assessment of the activity. Student takes notes, reads the recommended texts, organises him/herself with the other members of the working group, prepares a presentation with slides, memorises, and makes an oral presentation of the assigned topic.
Multiple-choice questions	Multiple-choice tests to be carried out through the Moodle platform of the course. Teacher asks questions and assesses the students' answers. Student consults his/her support materials and answers the questions asynchronously.
Objective test	Corresponds to the official exam of the subject. Teacher orepares a written test, with calculation exercises and multiple choice questions, and assesses students' answers. Student answers the questions individually and synchronously, without external support of any kind.

Personalized attention	
Methodologies	**Description**
Seminar Guest lecture / keynote speech ICT practicals	Every student will have 1 hour of obligatory tuition, with the objective of detecting possible dysfunctions of the teaching program and designing appropriate corrective actions.

Assessment			
Methodologies	**Competencies / Results**	**Description**	**Qualification**
Seminar	A7 A12 B1 B2 B3 B4 B5 B6 B7	Students will be presented with findings and hypotheses that in their day represented scientific revolutions in the knowledge of biological evolution, so that they can follow the course of subsequent research and assess their validity and impact today. The activity will take the form of a slide presentation, which must be presented and defended orally in front of the teaching staff and the rest of the students.	15
Multiple-choice questions	A7 A18 B1 B2 B3 B4 B5 B6	It consists of a series of multiple choice questionnaires on the Moodle platform, which must be answered on dates and at times set in advance throughout the course.	25

ICT practicals	A7 A21 B2 B4	Practical exercises of bioinformatics. Compulsory: to avoid failing the subject, every student should obtain at least 15 points in this exam.	25
Objective test	A7 A12 A18 A21 A24 B1 B2	It is a written test, face-to-face and synchronous, which corresponds to the official exam of the subject. It consists of a series of calculation exercises and multiple choice test questions. Compulsory: every student should obtain at least 21 points in this test to pass the subject.	35

Assessment comments
Official withdraw from the course is only possible if the student attends neither the final theoretical (objective test) nor the practical exam. In order to pass the subject, it will be necessary to achieve at least 50 points with the sum of the different evaluation methodologies, as long as the minimum mark required in the practical and the objective test has been achieved. The final grade of the students who did not reach the minimum mark to pass the course in the practical or the objective test, but whose cumulative score happened to be higher than 50, will be a 4.9 (FAILED). In the event that, for duly justified reasons, it is not possible to attend the official exam of the subject, an oral exam will be held, with a similar content to the written exam. If a student does not achieve the maximum possible scores in the continuous assessment activities, he/she may choose to take an additional block of questions in the final exam of the subject, on the understanding that he/she renounces the qualification he/she obtained before in the continuous assessment. The second opportunity will only be assessed by means of the practical exam and the objective test, using the same methodology as in the first opportunity. For the purposes of calculating the final grade, the marks obtained in the activities with continuous assessment (seminar and multiple-choice test) at the first opportunity will be maintained. For the computation of the final grade of students with recognition of part-time dedication and academic dispensation of attendance, both in the opportunity of the end of term and in the second opportunity, the grade obtained in the theoretical exam and the corresponding practical part (see above format of both exams) will be taken into account, representing 75% and 25% of the final grade, respectively. The fraudulent performance of the evaluation tests or activities will directly imply the grade of FAILED (0) in the corresponding call of the academic year, whether the commission of the fault occurs in the first opportunity or in the second one.

Sources of information	
Basic	- Hartl, D. L. (2020). A primer of population genetics and genomics. OUP Oxford - Cutter, A. D. (2019). A primer of molecular population genetics. OUP Oxford - Futuyma, D. J., and Kirkpatrick, M. (2017). Evolution. Sinauer Associates - Zimmer, C. and Emlen, D. (2015). Evolution: Making sense of life. Roberts and Company Publishers - Shubin, N. (2015). Tu pez interior. Capitán Swing - Lane, N (2018). Power, Sex, Suicide. OUP Oxford - Hahn, M. W. (2018). Molecular Population Genetics. OUP USA - Caballero, A. (2017). Genética Cuantitativa. Síntesis - Beukeboom, L., and Perrin, N. (2014). The evolution of sex determination. OUP Oxford - Hedrick, P.W. (2011). Genetics of Populations.. Jones & Bartlett - Herron, J. D., and Freeman, S. (2014). Evolutionary Analysis. . Pearson - DeSalle, R. (2013). Phylogenomics: A primer. Routledge

Complementary	- Avise, J. C. (2006). Evolutionary Pathways in Nature. A Phylogenetic Approach. . Cambridge Univ. Press. - Barton, N. (2007). Evolution. Cold Spring Harbor Lab. Press. - Bromham, L. (2008). Reading the Story in DNA: A Beginners Guide to Molecular Evolution. . Oxford Univ. Press. - Coyne, J. A. (2009). Why Evolution is True. Viking - Ridley, M. (2004). Evolution. Blackwell - Sampedro, J. (2007). Deconstruyendo a Darwin: Los Enigmas de la Evolución a la Luz de la Nueva Genética.. Síntesis - Fontdevila, A., y Moya, A. (2003). Evolución. Origen, adaptación y divergencia de las especies.. Síntesis - Fontdevila, A., y Moya, A. (1999). Introducción a la genética de poblaciones. Síntesis

Recommendations
Subjects that it is recommended to have taken before
Statistics/610G02005 Genetics/610G02019 Molecular Genetics/610G02020
Subjects that are recommended to be taken simultaneously
Subjects that continue the syllabus
Other comments
The contents of the syllabus and the support material for the study are in the Moodle platform of the UDC, so it is essential to connect to it, and pay attention to the news that both teachers and automatic servers will disseminate throughout the course. It is advisable to keep up to date with the material, attending classes, answering the questionnaires and solving the complementary exercises of the different topics. It is very helpful to understand written English, since most of the bibliography is in that language, and to know how to use EXCEL sheets at user level.