Teaching Guide				
Identifying Data				2021/22
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	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.			
Contingency plan	Adaptations that will be carried out in teaching and evaluation, in a scenario of non-presence due to a new outbreak of the pandemic, or in case that due to space problems in the classrooms it is not possible to guarantee 100% of presentiality for the expository teaching: 1.- In case of capacity problems in the spaces designated for the realization of face-to-face activities, additional spaces will be reserved in which students can follow the activities through the Teams UDC platform. In the case of practical activities, the groups will be divided to adapt to the capacity of the laboratory or computer room. 2.- Modifications in the contents No changes will be made. 3.- Methodologies The classes and other activities that cannot be developed in the classroom, due to the foreseeable measures of social distancing, will be developed telematically through the platform Teams UDC, for which a specific team of the subject will be created. Visits to external laboratories, integrated in the practices of the subject, will be suspended. 4.- Personalized attention to students It will be carried out by e-mail and Teams. 5. Modifications in the evaluation If necessary, all the tests will be telematic, through Teams and Moodle, with the webcams activated. 6. Modifications to the bibliography or webgraphy None.			

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
1.- GENETIC VARIATION	Different kinds of genetic variation and their quantification. The National Center for Biotechnology Information (NCBI) databases. The 1000 genomes project of human variation. Genome browsers (Ensembl). Genotype and phenotype.
2.- 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.
3.-THE BUILDING OF EVOLUTIONARY MODULES	Promiscuous proteins; molecular machines; modular evolution of proteins. Evolutionary tinkering. Biochemical construction kits. Adaptations, exaptations and spandrels. Evo-devo: recycling networks. Retrograde and intercalary evolution. Gene duplications. Recruitment. Horizontal transmission. Linkage groups. Randomization effect of recombination. Genetic coadaptation. Supergenes.

4.- 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
5.- 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.
6.- 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).
7.- 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.
8.- 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.
9.- 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.
10.- 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.
11.- COMBINED ACTION OF SELECTION AND OTHER EVOLUTIONARY FORCES. VARYING SELECTION COEFFICIENTS	Mutation-selection balance. The role of recombination: Muller's ratchet and the degeneration of Y chromosomes. Equilibrium between selection and gene flow; gene clines. Too much heterosis: segregational load. Negative frequency-dependent selection. Spatial and temporal variation in fitness: coarse grained vs fine grained environments. Antagonistic pleiotropy. Fitness trade-offs.
12.- 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.
13.- 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	1
Guest lecture / keynote speech	A7 A12 A18 A24 B1 B3 B4 B6	18	36	54
Problem solving	B2	6	12	18
ICT practicals	A7 A21 B2 B4	15	15	30
Directed discussion	B1 B2 B3 B7	1	0	1
Collaborative learning	A27 B1 B3 B5 B7	7	35	42
Objective test	A7 A12 A18 A21 A24 B1 B2	3	0	3
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	Profesor.- Presenta a guía docente da materia, aclara dúbidas, organiza os alumnos para as actividades. Alumno.- Toma notas, formula dúbidas e cuestións.
Guest lecture / keynote speech	Profesor.- Explica os fundamentos teóricos Alumno.- Observa, asimila e toma notas. Formula dúbidas e cuestións. Memoriza. Le os textos recomendados.
Problem solving	Profesor.- Formula problemas e orienta para a súa resolución. Alumno.- Traballa individualmente ou en grupo, busca información e resolve as cuestións formuladas
ICT practicals	Profesor. - Presenta os obxectivos, prepara o material e o equipo, expón os métodos, proporciona un guión, asiste aos alumnos. Alumno. - Experimenta, analiza e elabora unha memoria
Directed discussion	Discusión de textos asignados a principio do curso e resolución de exercicios relacionados.
Collaborative learning	(profesor) Asigna traballos. Instrúe sobre ferramentas. Orienta e resolve dúbidas. (alumno) Traballa cos seus compañeiros na realización das tarefas asignadas polo profesor.
Objective test	Profesor. - Formula preguntas e valora as respostas dos alumnos Alumno. - Consulta os seus materiais de apoio e responde ás preguntas

Personalized attention	
Methodologies	**Description**
Directed discussion Collaborative learning Guest lecture / keynote speech Problem solving 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**
Directed discussion	B1 B2 B3 B7	1 hour exam (test + exercises) related to the topics dealt with in the seminars.	15
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	Critical review of a scientific manuscript (value = 10), plus regularly spaced multiple-choice tests (cumulative value = 15), plus final theoretical exam consisting both of multiple-choice tests and populations genetics exercises (cumulative value = 35). Compulsory: to avoid failing the subject, every student should obtain at least 35 points in this part of the assessment.	60

Assessment comments
Official withdraw from the course is only possible if the student attends neither the final theoretical nor the practical exam. The final grade of the students who did not reach the minimum grade 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 second opportunity, the same evaluation methodology will be used as in the first one. In the event that a student, for duly justified reasons, cannot attend the official exams of the subject, he/she will be examined orally. If he/she is unable to take the continuous evaluation tests, or if he/she does not obtain the maximum possible points with these tests, he/she may take an additional block of exercises in the official exam, in order to recover the points lost. The fraudulent performance of the evaluation tests or activities will directly imply the grade of FAILED (0) in the subject at the corresponding opportunity.

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 - 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 - 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 teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.