VNIVERSITAT DE VALÈNCIA

Course Guide
44295 Palaeobiology and palaeontological systematics

COURSE DATA

Data Subject	
Code	44295
Name	Palaeobiology and palaeontological systematics
Cycle	Master's degree
ECTS Credits	4.5
Academic year	2024 - 2025

Study (s)

Degree	Center	Acad. year	Period
2200 - Master?s Degree in Applied Palaeontology	Faculty of Biological Sciences	1	First term

Subject-matter

Degree	Subject-matter	Character
2200 - Master?s Degree in Applied Palaeontology	1 - Fundamentals of palaeontology	Obligatory

Coordination

Name	Department
BOTELLA SEVILLA, HÉCTOR	200 - Geology
FERRON JIMENEZ, HUMBERTO GRACIAN	356 - Botany and Geology

SUMMARY

Evolutionary ideas and their history. The synthetic theory of evolution. The evolutionary reading of the fossil record: evolutionary rates and patterns of evolution. Micro and macroevolution. Basic notions of systems theory and its application to the theory of evolution. Individuals and selection units at their different levels. Phyletic Gradualism and Punctuated equilibrium. Decoupling between micro and macroevolution. Stochastic aspects of the evolution contemplated through paleontological data. Macroevolutionary mechanisms. Diversity and disparity: macroevolution and morphological evolution. The consideration of embryonic development (evo- devo). Notions of biomorphodynamics: Morphology as evidence of evolutionary change; the factors that determine the organic form; approaches to Evolutionary, Theoretical and Functional Morphologies; isometry and allometry. Concepts Limitations (constrained) on morphological evolution. Towards an expanded theory of evolution. Extinctions: their role in macroevolution. Types of extinctions: background extinction, mass and episodic. Stochastic aspects of extinctions. The classic causes of mass extinction. Biodiversity dynamics during the Phanerozoic: evolutionary faunas and flowers.

Implications of the evolutionary process in the classification of living things: Evolutionary conception of the tree of life. Taxonomy, Systematics and Classification. Fundamentals of phylogenetic reconstruction: character as a basic unit; use of homology in Systematics. Techniques, schools and computer tools for classification in paleontology. Taxonomic nomenclature codes. Construction of phylogenetic trees from morphological characters; cladograms. Management of software for cladistic analysis.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

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

Other requirements

There are no specified restrictions with other subjects of the curriculum. There are no enrollment restrictions with other subjects of the curriculum. However it is recommended a minimum knowledge of zoology, botany and ecology, as well as general Geology and Paleontology.

2200 - Master?s Degree in Applied Palaeontology

- Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.
- Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.
- Students should communicate conclusions and underlying knowledge clearly and unambiguously to both specialized and non-specialized audiences.
- Students should demonstrate self-directed learning skills for continued academic growth.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- Be able to access to information tools in other areas of knowledge and use them properly.
- To be able to assess the need to complete the scientific, historical, language, informatics, literature, ethics, social and human background in general, attending conferences, courses or doing complementary activities, self-assessing the contribution of these activities towards a comprehensive development.
- Be able to communicate and disseminate scientific ideas.
- Aplicar el razonamiento crítico y la argumentación desde criterios racionales.
- Aplicar la Ciencia desde la óptica social y económica, potenciando la transferencia del conocimiento a la Sociedad.

- Capacidad para preparar, redactar y exponer en público informes y proyectos de forma clara y coherente, defenderlos con rigor y tolerancia y responder satisfactoriamente a las críticas que pudieren derivarse de su exposición.
- Proyectar la inquietud intelectual y fomentar la responsabilidad del propio aprendizaje.

To know the theory of evolution, its postulates and its fields of application, and its impact on the development of science. Understand the historical nature of the evolutionary process, both in its own aspects of unrepeatability and contingency, as in those linked to compliance with the laws of the nature of all kinds and therefore of necessity. Recognize that biodiversity is the product of evolution as a process, this can only be shown by the fossil record, which allows sorting history of events. Understand also that biodiversity, in everything moment, it has been the product of the origin of new species accompanied by the extinction of some others already existing. Also understand the importance of events such as major crises (mass extinctions), which allow us to examine the before and after of the event and derive consequences practices. Understand the temporal dimension of the origin and evolution of life and its implications.

Differentiate between Systematics, Taxonomy and classification Know the different types of classification systems. Know the major taxonomic groups and their position in phylogenetic reconstruction universal. Distinguish between homologies and homoplasms. Recognize taxonomic categories i use the rules of biological nomenclature. Know the rules to follow to establish groups of organisms. Differentiate between natural selection and evolution. Build and interpret phylogenetic trees.

Manage in a basic way computer programs for the reconstruction of phylogenies (programs Phylip and TNT) and their use for the classification of organisms.

DESCRIPTION OF CONTENTS

1. NATURE OF THE FOSSIL RECORD

Chapter 1. The nature of the Fossil Record
-Nature and scope of Paleobiology
-Preservation of the fossil record
-Sampling the fossil record
-Completeness of the fossil record
-Rarefaction

Chapter 2. Populations, species and fossil record
-The species in paleontology.
-Actualistic aspects: speciation, pre- and postzygotic reproductive isolation, and biogeography.
-Determination of species: determination criteria.
-How species are inferred through the fossil record: their possibility of determination.
-Species in the fossil and stratigraphic records: spatial and tempo

2. GLOBAL DIVERSIFICATION AND EXTINTION

Chapter 3. Extinction (1).
-General aspects.
-Definition and modalities.
-Background, mass and episodic extinction.
-Extintion and cyclicity.
-Geometry of the mass extinction: gradual, stepwise and catastrophic.
-Stratigraphic limits of the mass extinction
-Taphonomy and limits of mass extinction.
-Lazarus effect (ecological shelters).
-Signor-Lipps effect (poor sampling).
-Specific crises and threshold crises.
-Chance and mass extinction: Galtonian extinction.
-Episodic extinction.
-Practical cases of extinction analysis.

Chapeter 4. Extinction (2).
-Causes.-
-Background extinction: conditions that lead to a critical population size.
-Selective vulnerability.
-The great crises: environmentalist and internalist explanations.
-Common Agents of Destruction vs. particular agents of each medium.
-The continuous spectrum of extinction magnitude (from background to episodic). -The responses of the species during the Phanerozoic.
-Climate as the major causal factor.
-Transgressions, regressions and generalized volcanism, and climate.
-Climate and cosmic phenomena: meteoritic impacts.
-Problematic aspects.-
-The end-Permian extinction.
-The end-Cretaceous extinction.

4. EVOLUTIONARY INTERPRETATION OF THE FOSSIL RECORD (2)

Rates and evolutionary trends
Macroevolution; Macroevolutionary Mechanisms
Evolutionary interpretation of the fossil record

T.7. Macroevolution: definition.
o Ecological time and t. evolutionary (or geological) .- Micro- and macroevolution.
o Evolutionary trends: their possible causes according to the modern synthesis.-
o Evaluation of evolutionary rates.-
o Evolution patterns: diversification, disparity, adaptive radiation, convergence and parallelism, and ecological replacement.-
o The reductionism of the modern synthesis.

T.8. Species or lineages.
o Morphological stasis: contradiction with traditional schemes.-
o Morphological stasis and speciation: Interrupted equilibrium.-
o Explanatory potential: evolutionary trends, Cambrian explosion, etc.-
o Interrupted equilibrium and natural selection.
o Decoupling between micro- and macroevolution.-
o Conclusion: the various positions in the face of organic change: directionality vs. its absence, internalism vs. environmentalism and saltationism vs. gradualism.
T. 10. Selection at various levels of the hierarchy
o The group: when is group selection possible? - Selection at the genome level.-
o Consequences.- Conflicts and synergisms between selection levels.-
o The disrupted equilibrium provides the basis for the individuality of the species.
T.9. Selection at various levels of the hierarchy
o The group: when is group selection possible? - Selection at the genome level.-
o Consequences.- Conflicts and synergisms between selection levels.-
o The disrupted equilibrium provides the basis for the individuality of the species.

6. EVOLUTIONARY MORPHOLOGY

-T.13. Theoretical Morphology
o Biomorphodynamics: the four factors.
o Traditional explanation of the forms
o Plan unit vs. functionality. - Forms in modern synthesis.-
o Variability and its restriction (constraints).
o Evo-devo; The importance of development in evolution. Limitations to natural selection: experiments by s. artificial. - Limitations to phenotypic variability: malformations. - The epigenetic landscape of Waddington.- Channeling and creods.- About orthogenesis: the teachings of development.
o The evolutionary pathways allowed by development: heterochronies - Development sequences: von Baer vs. Haeckel.- Embryonic similarities.- Heterochrony: definition and modalities.- The human case: neoteny or hypermorphosis? - Malformation and heterochrony.- The example of the extremities of vertebrates.

- T. 14. Functional Morphology
o Biomechanics
o Ecomorphology
o o Other evidences in Functional Morphology.

7. MULTIDISCIPLINARY CASE STUDIES IN PALEOBIOLOGY

- T.15. Multidisciplinary study cases in paleobiology
o Paleontology as an integrative science
o Case studies

8. Systematic Paleontology

opic M.17.- Systematics, taxonomy and Nomenclature; concepts. History of Biological classification. The Paleontological nomenclature; Biological Nomenclature Codes. Name formation scientists. Operating principles of the nomenclature; specimens and type taxa, typification principle; synonymic lists and nomenclatural changes; interpretation of taxonomic changes and Nomenclatural Erection and formal description of species .. Para-taxonomy in Paleontology. Nomenclature of disjointed elements. (2 hours)
Topic M.18.- Phylogenetic reconstruction in Paleontology. Theoretical principles of inference Phylogenetics. Trees and cladograms. Inference of phylogenies from morphological characters. Apomorphic and plesiomorphic characters. Determination of the polarity of the characters. The dimension
temporary in pedigrees (1 hour)
Topic M.19.- Phylogenies and classification. Inclusive taxonomic hierarchies. Taxonomic categories: usage
and application. Classification schools and group formation. The nature of the categories superiors. Stem-groups and Crown-groups in Paleontology (1 hour)

9. LABS

Session 1.- (LABORATORY 2 HOURS) The problem of biological classification. Character handling morphological. Character states. Registration of quantitative and qualitative characteristics; encoding and
character ordering. Elaboration of binary character matrices. Character handling complex. Elaboration of multistate character matrices.
Session 2.- (PROBLEMS 3 HOURS)
Principles of Phylogenetic Systematics. Stages of work. Character types and encoding. Criterion homology. Coding and polarity of characters according to the criteria of the external group, ontogenetic and stratigraphic. Application of parsimony in the contracting of phylogenetic hypotheses. Information obtained from phylogenetic hypotheses. Types of groups. Recognition of synapomorphies, plesiomorphies, autapomorphies, and their meaning. Principle of Simplicity. Parenthetical notation. Root and
rooting. Topologies. Manual elaboration of cladograms. Resolution of exercises.
Sessions 3 and 4.- (COMPUTER 3 HOURS X SESSION)
Cladistic methods II. Application of computer programs for phylogenetic reconstruction by parsimony. Algorithms Trees of minimum length. Character optimization. Tree parameters. Interpretation of the results obtained and their implications regarding the evolution of the characters. Consensus trees ... Support and statistical confidence of groups and trees. Interpretation of results and their implications in biological classification and nomenclatural aspects.

10. Seminar- Conferences

Seminar 1.- Conference on some of the leading topics in research * Paleobiological in issues such as (mainly) Macroevolution, Dynamics of extinctions, Evolutionary morphology etc. The topic of the conference may vary from one course to another depending on topics of special interest
at that time and the availability of seminarians. Students will present a comment about the seminar taught.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	34,00	100
Laboratory practices	11,00	100
TOTAL	45,00	

TEACHING METHODOLOGY

Theoretical classes (32 contact hours):

• **Methodology:**

- Master classes through computer presentations.

- the appropriate audiovisual resources that will previously be accessible to students through the university's teaching support platform (virtual classroom).

- Exhibition and public defense of group work

- Controls

- Tests and exams

Practical classes in computer science (6 contact hours) and problems (3 contact hours):

• **Methodology:**

- Introduction and planning of each practice

- Use of databases referring to the fossil record.

- Planning the calculation of evolution and extinction rates.

- Analysis of cohorts and pseudocohorts and highlight background extinction, episodic and mass.

- Application of parsimony in the contracting of phylogenetic hypotheses.

- Use of Algorithms to measure the similarity and distance between individuals. Quantitative data transformation. Grouping algorithms. Construction of taxonomic hierarchy dendrograms. Delimitation of groups.

- Use of advanced computer programs for phylogenetic reconstruction in Paleontology. Application to real data matrices of different groups of fossil organisms. Consensus trees and evaluation of results.

• Evaluable individualized work:

• For the practice sessions, lasting 2 hours, students will have a script, which must be read before each practice. The practical sessions will be of problems and computer science, where complementary exercises will be proposed to reinforce the studied concepts. During the session, the teacher will introduce the objective of the practice and will remember the basic concepts to handle in the proposed exercises. During the rest of the session the students will carry out the practice or solve exercises under the supervision of the teacher

• Completion of the corresponding report.

• **Seminars** (2 face-to-face hours):

• **Methodology:**
- Attendance at conferences, field work and/or specialized theoretical and practical seminars that complement your training.
- Elaboration of various materials and documents in theoretical and practical activities.
- Assessable individual work:

• Elaboration of reports on exposed contents.

• Preparation of previous documentation.

• Realization of reports

EVALUATION

- A final prove (exam or oral presentatión)

- Memory of theseminar according to models provided to the student.

- Final practical test in the Computer Science classroom. Practical exercise of using the software used during the course with simulated paleontological data

It will also take into account:

• Attendance and use of classes.

• Practical jobs.

• Participation in seminars.

Assessment activity Weighting

Final test 75%

Computer classroom exercise 10%

Practical work and participation 15%

REFERENCES

Basic

- Foote, M. and Miller, A (2007) Principles of PAleontology. W. H: Freeman, New York
- Eldredge, N. 1985. Unfinished Synthesis. Biological Hierarchies and Modern Evolutionary Thought. 237 pp. Oxford University Press, Oxford.
- Eldredge, N. 1985. Time Frames. The Evolution of Punctuated Equilibria. 240 pp. Princeton University Press, Princeton.
- Eldredge, N. & Cracraft, J. 1980. Phylogenetic patterns and the Evolutionary Process. Method and Theory in Comparative Biology. 349 pp. Columbia University Press, New York.
- Gould, S.J. 1977. Ontogeny and Phylogeny. 501 pp. The Belknap Press of Harvard University Press, Cambridge (Massachusetts).
- Gould, S.J. 2004. La estructura de la teoría de la evolución. 1426 pp. Colección Metatemas nº 82. Ed. Tusquets.
- Hallam, A., ed. 1977. Patterns of Evolution as Illustrated by the Fossil Record. 591 pp. Elsevier Scientific Publishing Company, Amsterdam.
- Mayr, E. & Provine, W.B., eds. 1980. The Evolutionary Synthesis. Perspectives on the Unification of Biology. 487 pp. Harvard University Press, Cambridge (Massachusetts).
- Raup, D.M. 1986. El Asunto Némesis. Una Historia sobre la Muerte de los Dinosaurios. 242 pp. (traducción castellano 1990). Alianza Editorial, Madrid.
- Simpson, G.G. 1944. Tempo and Mode in Evolution. 237 pp. (reedición de 1984). Columbia University Press, New York.
- Sober, E., ed. 1986. Conceptual Issues in Evolutionary Biology. An Anthology. 725 pp. A Bradford Book, The MIT Press, Cambridge (Massachusetts).

- Stanley, S.M. 1979. Macroevolution. Pattern and Process. 332 pp. W.H. Freeman and Company, San Francisco.
- Vrba, E.S. & Eldredge, N., eds. 2005. Macroevolution. Diversity, Disparity, Contingency. 210 pp. Suplemento de Paleobiology, 31(2).
- Goloboff P A, Farris J S, Nixon K C (2008a) TNT, a free program for phylogenetic analysis. Cladistics 24: 1-13.
  http://www.cladistics.com/aboutTNT.html
- http://www.ucmp.berkeley.edu/clad/clad1.html
- Wiley, E.O., D. Siegel-Causey, D.R. Brooks, and V.A. Funk. 1991. The Compleat Cladist: A primer of phylogeny procedures. University of Kansas Press, Museum of Natural History, Special Publication no. 19. 1158 pp.

Additional

- Maddison, W.P., and D.R. Maddison. 1992. MacClade: Analysis of phylogeny and character evolution. Version 3.0. Sinauer Associates, Sunderland, MA.
- D.L. Swofford. 1991. Phylogenetic Analysis Using Parsimony (PAUP), version 3.0s. Illinois Natural History Survey, Champaign, IL.
- López Caballero E. y Peréz Suarez, G.1999 Metodos de análisis en la reconstrucción filogenética. Bol. S:E:A: nº 26. 45-56.
- Ribera, I y Melic A. 1996 Introduccion a la metodología y sistematica cladistica. Bol. S.E.A. 15 27-46.
- Buss, L.W. 1987. The Evolution of Individuality. 203 pp. Princeton University Press, Princeton.
- Bunge, M. 1981. Materialismo y Ciencia. 235 pp. Editorial Ariel, Barcelona.
- Erwin, D.H. & Wing, S.L., eds. 2000. Deep Time. Paleobiologys Perspective. 371 pp. Suplemento de Paleobiology, 26(4).
- Hull, D.L. 1989. The Metaphysics of Evolution. 331 pp. State University of New York Press, Albany.
- Lamolda, M., ed. 2003. Bioevents: their Stratigraphical Records, Patterns and Causes. 141 pp. Editado Por Ayuntamiento de Caravaca de la Cruz, Murcia.