VNIVERSITAT DE VALÈNCIA

Course Guide
46736 Palaeobiology and palaeontological systematics

COURSE DATA

DATA SUBJECT

Code: 46736
Name: Palaeobiology and palaeontological systematics
Cycle: Master's Degree
ECTS Credits: 4.5
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
2266 - Master's Degree in Applied Palaeontology	Facultat de Ciències Biològiques	1	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2266 - Master's Degree in Applied Palaeontology	Fundamentals of palaeontology	COMPULSORY

COORDINATION

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SUMMARY

The course in Paleobiology and Paleontological Systematics covers a wide range of fundamental topics to understand the evolution and classification of living organisms over geological time. We will begin by exploring evolutionary ideas and their history, from early speculations to the synthetic theory of evolution, integrating genetics and natural selection. We will analyze the evolutionary reading of the fossil record to interpret evolutionary rates and patterns, distinguishing between microevolution and macroevolution. Basic concepts of systems theory and its application to evolution will be introduced, along with studying individuals and units of selection at different levels. Gradualism and punctuated equilibrium will be discussed, as well as the decoupling between micro and macroevolution. The stochastic aspects of evolution, observed through paleontological data, will also be considered.

We will address macroevolutionary mechanisms and the relationship between diversity and disparity in morphological evolution, including the consideration of embryonic development through evo-devo. Concepts of biomorphodynamics will be presented, analyzing morphology as evidence of evolutionary change and the factors that determine organic form, with approaches to evolutionary, theoretical, and functional morphologies, as well as isometry and allometry. We will discuss the constraints on morphological evolution and move towards an extended theory of evolution. The role of extinctions in

macroevolution will be a central topic, classifying extinctions into background, mass, and episodic, and examining the classical causes of mass extinctions.

We will study the dynamics of biodiversity during the Phanerozoic, including evolutionary faunas and floras. We will analyze the implications of the evolutionary process in the classification of living organisms, with an evolutionary conception of the tree of life. Taxonomy, systematics, and classification will be reviewed, along with the fundamentals of phylogenetic reconstruction, highlighting the use of homology in systematics. Techniques, schools, and computer tools for classification in paleontology will be addressed, including taxonomic nomenclature codes, and the construction of phylogenetic trees from morphological characters, including the use of cladograms. Finally, the course will include the handling of software for cladistic analysis, providing a comprehensive and practical understanding of paleontological systematics.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

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

OTHER REQUIREMENTS

No enrollment restrictions with other courses in the study plan have been specified. It is recommended, though not essential, to have basic knowledge of zoology, botany, and ecology, as well as geology and paleontology.

COMPETENCES / LEARNING OUTCOMES

2266 - Master's Degree in Applied Palaeontology

Access information tools from other areas of knowledge and use them appropriately.

Access the necessary information in the specific field of the subject (databases, scientific articles, etc.) and have sufficient judgement to interpret and use it.

Apply critical reasoning and argumentation based on rational criteria.

Apply science from a social and economic point of view, promoting the transfer of knowledge to society.

Apply the knowledge acquired and problem-solving abilities in new or unfamiliar situations within broader (or multidisciplinary) contexts related to the field of study.

Apply the research experience acquired to initiate the research phase of a PhD programme on biodiversity-related topics.

Apply the research experience acquired to tasks specific to the profession, both in the private sector and in public institutions.

Assume an ethical commitment and sensitivity towards environmental problems and natural and cultural heritage.

Be familiar with, develop and manage georeferenced databases of elements from the geological and palaeontological record, as well as the software used for the spatial representation and analysis of these elements.

Communicate and popularise scientific ideas.

Communicate conclusions and the knowledge and rationale supporting them to specialised and non-specialised audiences clearly and unambiguously.

Conduct studies, applying the methods and techniques needed to preserve and manage palaeontological heritage.

Continue the learning process in a manner that is largely self-directed or independent.

Demonstrate in-depth understanding of the historical nature of the evolutionary process, both in its aspects of unrepeatability and contingency and in those linked to the fulfilment of laws of nature of all kinds and, therefore, of necessity.

Demonstrate intellectual curiosity and encourage responsibility for one's own learning.

Demonstrate knowledge and understanding of the legal foundations for the protection and conservation of palaeontological heritage at the level of the EU, Spain and the Spanish Autonomous Communities.

Develop experimental skills in the handling of laboratory material and equipment in palaeontology.

Integrate knowledge and confront the complexity of making judgements based on information that, although incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of knowledge and judgements.

Know, understand and draw conclusions, applicable to the present time, about the crises of biological diversity, and their causes and consequences within the framework of actualism.

Know and confidently handle the divisions of the geological time scale and the biostratigraphic scales constructed from different groups of biota in the fossil record.

Know and understand past biological events, as well as the zonations, in time and space, of biota in order to establish the relative stratigraphic position of sedimentary rocks from different geographical areas.

Know and understand the palaeodiversity of living beings, their ecosystemic relationships and the palaeogeographical distribution achieved by the main groups of living beings throughout the Earth's history.

Learn about the techniques used in museums for the management of palaeontological heritage, identifying, during guided work visits, successful examples in the field of palaeontology (Dinópolis, the Catalan Institute of Palaeontology, the Palaeontological Museum of Elche).

Make quick and effective decisions in complex situations in their professional or research work, by developing new and innovative work methodologies adapted to the scientific/research, technological or professional field in which they carry out their activity.

Plan and manage available resources, taking into account the basic principles of quality, risk prevention, safety and sustainability.

Prepare, write and present reports and projects in public in a clear and coherent manner, defend them with rigour and tolerance and respond satisfactorily to any criticism that may arise from the presentation.

Produce all types of reports related to palaeontological matters clearly and concisely at an official or professional level (reports, grants, heritage impact reports, research projects, etc.)

Understand the nature of the stratigraphic record, its discontinuities, cycles and events, the different types of sedimentary basins, the factors controlling their infilling, the resulting three-dimensional geometries and stratigraphic correlations.

Use acquired knowledge as a basis for originality in the development or application of ideas, often in a research context.

Work efficiently in a professional or research team, acquiring the ability to participate in research projects and scientific or technological collaborations.

DESCRIPTION OF CONTENTS

1. THEORETICAL MODULE

1. Paleobiology: Introduction

1.1. Basic Concepts and Historical Context

- Definition of paleobiology and its relevance.
- Historical milestones in the study of fossils.

1.2. The Nature of the Fossil Record

- Geographic and Environmental Distribution of Fossiliferous Rocks
- Potential for Fossil Record Preservation
- Measures of (In)completeness of the Fossil Record
- Sampling of the Fossil Record

1.3. The Species in Paleontology

- The Concept of Species
- Species and Speciation
- Recognition of (Morpho)species in the Fossil Record
- (Morpho)species in the Fossil Record and Geological Time

2. Global Diversification and Extinction

2.1. Basic Concepts and Historical Context

2.2. Global Diversification

- Methods for Constructing Global Diversity Curves
- Development of the Coupled Logistic Model
- Alternative Scenarios to the Coupled Logistic Model
- Evolutionary Faunas in Continental Environments

2.3. Extinction

- Background Extinction vs. Mass Extinction
- Background Extinction
  Vulnerability to extinction and selectivity.

- Mass Extinction
  Is there cyclicity in mass extinctions?
  Possible biases in the study of extinctions.

2.4. Recovery from Mass Extinctions

- Phases of Recovery
- The Evolutionary Significance of Mass Extinctions

2.5. Dynamics of Origination

- Possible Key Role in Mass Extinctions
- Trends in Origination (and Extinction) Rates in Marine Environments
- Dynamics of Origination in Terrestrial and Marine Environments

2.6. Diversification and Extinction in the Phanerozoic

- Ecological Alterations Associated with Extinction and Diversification Processes
- Causes of Extinction
  Triggers vs. Mechanisms of Extinction.

- Main Events of Diversification and Extinction in the Phanerozoic

3. Evolutionary Interpretation of the Fossil Record

3.1. Microevolution vs. Macroevolution

3.2. Reductionism, Gradualism, and Punctuated Equilibrium

- Phyletic Gradualism (Diagonal Model)
- Punctuated Equilibrium (Rectangular Model)
- Stanley's Proposals

- Challenges to Stasis
- Conditions for Testing Punctuated Equilibrium
- Implications for Evolutionary Theory
- Mechanisms of Stasis
- The Role of Regulation and Mobilization of Transposable Elements

3.3. Evolutionary Patterns

- Evolutionary Trends: Dynamics, Causes, and Bases
- Critique of Orthogenesis as a Mechanism for Generating Evolutionary Trends
- Diversification and Morphological Divergence (Disparity)
- Ecological Replacement
- Convergence, Parallelism, Reversal, and Iterative Evolution

3.4. Selection (Multilevel), Adaptation, and Exaptation

- Natural Selection
- Selection in Abstract Terms
- Multilevel Selection
- Adaptation and Exaptation

4. Evolutionary Morphology

- Biomorphodynamics: The Four Factors
- Traditional Explanation of Forms
- Body Plan vs. Functionality in Modern Synthesis
- Evo-Devo: The Importance of Development in Evolution
  - Limitations to Natural Selection: Artificial Selection Experiments.
  - Limitations to Phenotypic Variability: Malformations.
  - Waddington's Epigenetic Landscape: Canalization and Creodes.
  - Lessons from Development about Orthogenesis.

- Evolutionary Pathways Allowed by Development: Heterochronies
  - Developmental Sequences: Von Baer vs. Haeckel
  - Embryonic Similarities
  - Heterochrony: Definition and Modalities

- Biomechanics
- Ecomorphology
- Other Evidence in Functional Morphology

5. Multidisciplinary Case Studies in Paleobiology

- Paleontology as an integrative science

- Case studies

6. Paleontological Systematics

6.1. Systematics, Taxonomy, and Nomenclature

- Concepts
- History of biological classification
- Paleontological nomenclature
- Biological nomenclature codes
- Formation of scientific names
- Operational principles of nomenclature
- Type specimens and taxa
- Principle of typification
- Synonymic lists and nomenclatural changes
- Interpretation of taxonomic and nomenclatural changes
- Erection and formal description of species
- Parataxonomy in paleontology
- Nomenclature of disarticulated elements

6.2. Phylogenetic Reconstruction in Paleontology

- Theoretical principles of phylogenetic inference

- Trees and cladograms
- Phylogeny inference from morphological characters
- Apomorphic and plesiomorphic characters
- Determining character polarity
- The temporal dimension in genealogies

6.3. Phylogenies and Classification

- Inclusive taxonomic hierarchies
- Taxonomic categories: use and application
- Classification schools and group formation
- The nature of higher-level categories
- *Stem-groups* and *Crown-groups* in paleontology

2. PRACTICAL MODULE

Session 1: Laboratory

- The Problem of Biological Classification
- Handling of Morphological Characters
- Character States

- Recording of Quantitative and Qualitative Characters
- Coding and Sorting of Characters
- Construction of Binary Character Matrices
- Handling of Complex Characters
- Construction of Multistate Character Matrices

Session 2: Problems

- Principles of Phylogenetic Systematics
- Work Stages
- Types of Characters and Coding
- Criterion of Homology
- Character Coding and Polarity According to the Outgroup, Ontogenetic, and Stratigraphic Criteria
- Application of Parsimony in the Testing of Phylogenetic Hypotheses
- Information Obtained from Phylogenetic Hypotheses
- Types of Groups
- Recognition of Synapomorphies, Plesiomorphies, Autapomorphies and Their Significance
- Principle of Simplicity
- Parenthetic Notation
- Root and Rooting

- Topologies
- Manual Construction of Cladograms
- Problem Solving

Sessions 3 and 4: computer practicals

- Cladistic Methods
- Use of Software for Phylogenetic Reconstruction by Parsimony
- Algorithms
- Minimum Length Trees
- Character Optimization
- Tree Parameters
- Interpretation of Results Obtained and Their Implications
- Consensus Trees
- Statistical Support and Confidence of Groups and Trees
- Interpretation of Results and Their Implications for Biological Classification and Nomenclatural Aspects

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	34,00
Laboratory	11,00

Total hours	**45,00**

NON PRESENCIAL ACTIVITIES

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

TEACHING METHODOLOGY

Theoretical Classes (34 hours in-person)

Methodology:

- **Lectures:** Delivered through PowerPoint presentations to facilitate the understanding of key concepts.
- **Audiovisual Resources:** All necessary materials will be available on the university's teaching support platform (virtual classroom), ensuring early access for students.
- **Assessments:** Tests and exams will be conducted to measure learning progress.

Practical Classes (6 hours in-person) and Problem-Solving Sessions (3 hours in-person)

Methodology:

- **Introduction and Planning:** Each session will start with a detailed introduction to the practice, establishing clear objectives.
- **Use of Databases:** Students will work with databases related to the fossil record for in-depth and relevant analysis.
- **Calculation of Evolution and Extinction Rates:** Students will learn to plan and calculate evolution and extinction rates.
- **Cohort Analysis:** Focus will be on analyzing cohorts and pseudocohorts, identifying different types of extinction (background, episodic, and mass).
- **Application of Parsimony:** Instruction on applying parsimony in formulating phylogenetic hypotheses.
- **Use of Algorithms:** Exploration of algorithms to measure similarity and distance among individuals, including the transformation of quantitative data and construction of hierarchical dendrograms.
- **Advanced Software Tools:** Utilization of specialized software for phylogenetic reconstruction in Paleontology, applying real data matrices from various fossil groups and generating consensus

trees.

Individualized Evaluative Work

- **Practice Guidelines:** Each student will have a guide to read before each practical session. Practices will be organized into problem-solving and computer sessions, presenting complementary exercises to reinforce learned concepts.
- **Practice Objectives:** At the beginning of each session, the instructor will present the specific objective of the practice and review the fundamental concepts to be applied in the exercises.
- **Instructor Supervision:** During the practice, students will work autonomously with continuous supervision and support from the instructor.
- **Report Preparation:** Each student must submit a corresponding report reflecting the work done and the knowledge acquired.

EVALUATION

Evaluation Components

- **Final Exam:** This will consist of a written exam combining multiple-choice questions, short answer questions, and development questions, allowing for a comprehensive assessment of the knowledge acquired.
- **Final Practical Test:** This will take place in the computer lab and will consist of a practical exercise using the software learned throughout the course, applying simulated paleontological data.

Additional Considerations

In addition to the above components, the following will be taken into account:

- **Attendance and Engagement:** Attendance in classes and the engagement with the proposed activities.

Weighting

- **Final Exam:** 75%
- **Computer Lab Exercise:** 10%
- **Practical Work and Participation:** 15%

This evaluation structure is designed to provide a comprehensive assessment of student performance, encouraging both theoretical and practical learning.

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- 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.