University of Lille
FIRST SEMESTER
PANGEA TRACK/PROFILE: ALL

TITLE OF UNIT: Applications of Palaeontology

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITIES (either in term of skills or knowledge or units to be validated before registration to this course): **basic knowledge in Palaeontology, and, or zoology**

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 8h
Practicals: 8h
Tutorials: 8h

Personal workload (hours expected to be dedicated to, including supervised projects): **60 hours**

Description of the module

General aims

The aim of this module is to introduce the different applications of palaeontology, and the practical setting and management of a palaeontological project (definition of goals, methods, schedule, and cost estimate).

Expected outcomes (knowledge)

At the end of this module, the student is expected to know how to:

- Identify potential fossils to be found in asection according to the sedimentary environment and to set a field methodology (sampling strategy), and the appropriate laboratory protocol, from extraction or preparation to imaging.
- Apply the adequate fossil group and stratigraphic method depending on the facies available and the objectives of the study.

Expected outcomes (skills)

- definition and management of a palaeontological project applied to basin analysis, basin exploitation, environmental studies, research.

Content summary

The different steps of implementation of a palaeontological project are first introduced: identification of the scientific, technical, and, or possibly commercial aims; management (sampling strategies, analytical methods, sample expedition, collection of connected-data). Different applications of palaeontology are also illustrated such as environmental palaeontology and integration of palaeontological data in sequence stratigraphy. For each, implications for prospects (energy, minerals, mapping, structural geology) or environmental project will be introduced. Practicals and tutorials will be as much as possible dedicated to case-studies.

Person in charge of the unit (first and last name, e-mail)

Sebastien CLAUSEN
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EVALUATION MODE (final exam, oral defence, report,...)	Ratio of the final grade
Final exam	**2/3**
Ongoing assessment	**1/3**

TITLE OF UNIT: Biostratigraphy

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITES (either in term of skills or knowledge or units to be validated before registration to this course): /

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures:8 h
Practicals: 8 h
Tutorials: 8 h

Personal workload (hours expected to be dedicated to, including supervised projects): **60 hours**

Description of the module

General aims

Biostratigraphy is fundamental for sedimentary geology and basin analysis, with industrial applications, but also for elucidating tectonic problems, evolutionary events, paleoceanographic reconstructions and for the study of past global environmental change. The objective of the course is to familiarize the student with the various methods of subdividing and correlating sedimentary sequences by using the fossil record.

Expected outcomes (knowledge)

The student will acquire first-hand experience through case studies and the use of specialized software used in the hydrocarbon industry. The training offered during this course will allow students to understand how biostratigraphy works in practice to subdivide and correlate sedimentary sequences, including some of its applications (e.g. estimation of sedimentary rates/construction of an age model, exploration of a hydrocarbon field, paleogeography, tectonics, etc.).

Content summary

At first will be presented the theoretical background behind the design of different types of biozonations (contiguous *versus* discontinuous) and of biozones (taxon range, interval and assemblage zones). The methods of quantitative biostratigraphy and graphic correlation will be presented afterwards. Through the analysis of a publication of his/her own choice, the student will have the opportunity to study a real case study in order to appreciate the way in which biostratigraphy works. Examples of biozonations and biozones will be analysed during the practical classes.

Person in charge of the unit (first and last name, e-mail)

DANELIAN Taniel
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EVALUATION MODE (final exam, oral defence, report,...)	Ratio of the final grade
Final exam	**70%**
Ongoing assessment (case studies)	**30%**

TITLE OF UNIT: Carbonate facies analysis

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITIES (either in term of skills or knowledge or units to be validated before registration to this course): **Background in carbonate facies analysis.**

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures:6h
Practicals: 18 h
Tutorials: /

Personal workload (hours expected to be dedicated to, including supervised projects): **60 hours**

Description of the module

General aims

The study of palaeoenvironments and the evolution of ecosystems and triggers of global change (i.e. climate change) has become a major topic in palaeontology in response to growing interest and pressure from civil society.
This module aims to provide students with practical skills in the caracterisation of palaeoenvironments and associated fossil assemblages based on macrofacies and microfacies analyses.

Expected outcomes (knowledge)

- Carbonate depositional environments (generalized facies model and standard microfacies).

Expected outcomes (skills)

- Recognition of depositional settings based on integrated facies analysis, from macrofacies to microfacies.

Content summary

This units mostly focuses on practical study of macro and microfacies and their interpretation based on most acknowledged standard models. The interpretation of community changes as environmental proxies (sea level, temperature, palaeogeography) will be illustrated through case studies.

Person in charge of the unit (first and last name, e-mail)

Sebastien CLAUSEN
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EVALUATION MODE (final exam, oral defence, report,...)	Ratio of the final grade
Final exam	¼
Ongoing assessment	¾

TITLE OF UNIT: English Scientific Writing and Communication

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITIES (either in term of skills or knowledge or units to be validated before registration to this course): **English B2 level.**

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 10 h
Practicals: 10 h
Tutorials:

Personal workload (hours expected to be dedicated to, including supervised projects): **55 hours**

Description of the module

General aims

This module is intended for students who will pursue a research career; its aim is to develop skills in scientific communication, from literature-monitoring to technical writing and other ways to communicate results to different audiences.

Expected outcomes (knowledge and skills)

At the aim of the unit, students are expected to know how to:
- retrieve information from scientific literature
- establish efficient strategies in automated-monitoring (search alerts)
- assess the quality and relevance of collected data
- organize a reference database.
- know the different publication medias, and the different types of papers and their specificity
- Organize and write a scientific paper
- Communicate scientific results to peer or large audience through oral presentation and poster.

Content summary

The different parts of the module include:
- Scientific publishing-practices (peer-review, traditional *vs* electronic publishing companies, open archive, monitoring, etc)
- Bibliometric indicators: information, utility, impacts of communication for scientists and institutions.

- A guide to good ethical practices in science communication (e.g., avoiding plagiarism, author list, acknowledgment of funding, etc.)
- Scientific writing (papers and reports) and publication strategies
- Scientific communication: posters and oral presentation (form short communications to seminars)
- Introduction to the rhetoric

This course is offered by the Graduate Programme "Science for a Changing Planet" of the University of Lille (http://www.isite-ulne.fr/index.php/en/graduate-programme-science-for-a-changing-planet/)

Person in charge of the unit (first and last name, e-mail)

Sophie DUQUESNE, sophie.duquesne@univ-lille.fr
Céline TOUBIN, celine.toubin@univ-lille.fr

EVALUATION MODE (final exam, oral defence, report,...)	Ratio of the final grade
Ongoing assessment	**100 %**

MODULE : Geobiosphere interactions in deep time

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITIES (either in term of skills or knowledge or units to be validated before registration to this course):

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 6h
Practicals: 6h
Tutorials: 8h

Personal workload (hours expected to be dedicated to, including supervised projects): **40 hours**

Description of the module

General aims

The aim of this module is to illustrate the history of the Earth System and long term interactions between the Geosphere (large scale physical and chemical processes) and the Biosphere by stressing on some major evolutionary events and their relation to global environmental change.

Expected outcomes (knowledge and skills)

- Understand the coupling between the Geosphere and the Biosphere through geological time.
- Understand, analyze, and communicate on this interdisciplinary topic through understanding of scientific papers.

Content summary

A historical overview will be presented of the coevolution of the Earth system and its Biosphere, by stressing on the evolution of life in relation to global tectonic, oceanographic and climate change and biogeochemical cycles. The origin of life, its early evolution in Precambrian oceans, the rise of animals during the "Cambrian explosion", terrestrialisation, Phanerozoïc diversifications and mass-extinctions and the significance of the calcite - aragonite and biogenic silica cycles will be developed as case studies. Students will be asked to prepare a short literature review based on relevant scientific papers.

Person in charge of the unit (first and last name, e-mail)

Taniel DANELIAN
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EVALUATION MODE (final exam, oral defence, report,...)	Ratio of the final grade
Ongoing assessment (literature review and analyse)	**1/3**
Final exam	**2/3**

TITLE OF MODULE: Introductory micropalaeontology

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITIES (either in term of skills or knowledge or units to be validated before registration to this course): **basic knowledge in paleontology, and, or zoology.**

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures :8h
Practicals: 8 h
Tutorials: 8h

Personal workload (hours expected to be dedicated to, including supervised projects): **60 hours**

Description of the module

General aims

The objective of this module is to provide an overview of **all** microfossil groups and their applications in Geosciences (biostratigraphy, palaeoenvironments, palaeoceanography), in Environmental (anthropogenic pollution) and Evolutionary studies (macroevolution, mass extinctions), but also in Geoarcheology and Forensic studies.

Expected outcomes (knowledge)

High rank taxonomic aspects of all microfossil groups are presented (through lectures and practicals) in order to help the student to understand and familiarize with the most significant and discriminating morphological characters of each group.

Content summary

An overview of all microfossil groups is presented (carbonate, siliceous, organic walled), the methods for their search and processing techniques, as well as the spectrum of their applications. For each fossil group, an introductory lecture will be followed by observations under a binocular and/ petrographic microscope (and sometimes the Scanning Electron Microscope).

Person in charge of the unit (first and last name, e-mail)

Catherine CRONIER
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EVALUATION MODE (final exam, oral defence, report,...)	Ratio of the final grade
Final exam	**60%**
Ongoing assessment	**40 %**

TITLE OF MODULE: Phylogenetics

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITES (either in term of skills or knowledge or units to be validated before registration to this course): /

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 6h
Practicals: 6h
Tutorials: 6h

Personal workload (hours expected to be dedicated to, including supervised projects): **40 hours**

Description of the course:

General aims

The objective of this course consists in apprehending a number of methods used in phylogenetic analyses in paleontology.

Expected outcomes (knowledge and skills)

By the end of the unit, students are expected to know how:

- to use the main softwares (PAST, PAUP, R packages) dedicated to phylogenetic analyses;
- to set up and run phylogenetic analyses of different fossil groups,
- to analyse and interpret results of phylogenetic analyses.

Content summary

The course includes the teaching of taxonomic and phylogenetic methods applied in the classification of Life (concepts, principles and methods), including cladistics methods useful to reconstruct the relationships based on inherited characters and phenetic methods to construct “distance” trees based on the overall similarity and understanding “molecular clocks, with the use of computer software (PAUP, PAST, R packages).

Person in charge of the unit (first and last name, e-mail)
Catherine CRONIER
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EVALUATION MODE (final exam, oral defence, report,...)	Ratio of the final grade
Supervised project	**30%**
Final exam	**70%**

TITLE OF UNIT : Geobiology

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITES (either in term of skills or knowledge or units to be validated before registration to this course):

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 6h
Practicals: 2h
Tutorials: 10h

Personal workload (hours expected to be dedicated to, including supervised projects): **40 hours**

Description of the course

General aims

This course provides an overview of some crucial steps in the co-evolution of life and environments, from the origin of life until the evolution of large animals. It is aimed at training future researchers in the application of novel, individual characterization of organic and mineral fossils to overcome the limits of conventional morphological studies for fundamental/applied paleontology. This course complements other fundamental/applied courses on mineral/organic diagenesis.

Expected outcomes (knowledge and skills)

At the end of the course, student are expected to:
- Understand the essential close coupling between biogeochemistry, mineralogy and paleontology in order to decipher ecosytems and paleoenvironments, for a better knowledge of the early evolution of life in extreme environments of primitive earth
- Master advanced characterization techniques for Geomicrobiology, biogeochemistry and paleontology
- Know how to apply the introduced analytical techniques and how to transpose their knowledge of microbial metabolism to applied environmental studies such as the investigation/remediation of polluted sites

Content summary

Microbial metabolism and microbial zonation. Chemical reactions performed by microbes will be studied in order to understand the early evolution of life, their roles in carbon, nitrogen, sulfur, iron and phosphorus cycles, and their impact on the transformation of Earth into a habitable planet.

Biomineralization processes will be overviewed to explain e.g. the mineral signatures of early microbial life, the removal of iron from early Earth oceans, the recording of geochemical metabolic signatures. Microbial mineralization, adsorption and bioweathering will also be studied for palaeontological and environmental applications such as investigation/remediation of polluted sites. **Post-mortem alteration (taphonomy) of microorganisms** will be covered to understand what morphological, molecular and isotopic features can help the taxonomic/metabolic identification of fossil.

The Archean-Proterozoic fossil and geochemical records will be reviewed in order to decipher the co-evolution of the earliest life forms and of paleoenvironments (oxygenation, glaciations, atmospheric CH_4/CO_2) until the advent of animals.

Molecular signatures (biomarkers) will be studied as paleontological and paleoenvironmental tools.

Advanced characterization techniques for Geomicrobiology, biogeochemistry and paleontology will be presented. A lab session will train students to autonomous use of Raman spectromicroscopy (to identify carbonate biominerals and perform organic matter thermometry (application to oil resources, taphonomy and metamorphism).

Case studies will be reviewed by students using existing controversial publications.

Person in charge of the unit (first and last name, e-mail)

Kevin LEPOT
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EVALUATION MODE (final exam, oral defence, report,...)	Ratio of the final grade
Ongoing assessment	**20%**
Final exam	**80%**

TITLE OF UNIT: Quantitative palaeontology

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITES (either in term of skills or knowledge or units to be validated before registration to this course): /

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 6h
Practicals: 6h
Tutorials: 6h

Personal workload (hours expected to be dedicated to, including supervised projects): **40 hours**

Description of the course

General aims

The objective of this course consists in apprehending a number of analytical methods applied in the study of fossil assemblages at various temporal and spatial scales.

Expected outcomes (knowledge and skills)

By the end of the unit, students are expected to know how:

- to use the main softwares (PAST, TPS, R packages) dedicated to morphometrics and palaeobiogeography;
- to set up and run appropriate analyses depending the hypothesis to be tested and the studed fossil group,
- to analyse and interpret results of quantitative analyses including palaeobiodiversity, palaeogeography and morphometrics.

Content summary

The course includes the teaching of:

-Basic numerical and statistical tools applied to database that are accumulated along research studies. Data are computed by using the free software R.

- Analytical methods to study paleobiogeographic patterns with the use of computer software, including concepts and methods of PAE (Parsimony Analysis Endemics), BPA (Brook's Parsimony Analysis), etc.
- Methods of geometric morphometrics (Procrusts, Fourier transforms) with the use of computer software (TPS series, R packages) and based on different shape parameters (landmarks, sliding semi-landmarks, outline).

- Setting and analysis of palaeobiodiversity curves based on specially designed databases, including analytical methods that allow to explore various biases.

Person in charge of the unit (first and last name, e-mail)
Catherine CRONIER
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EVALUATION MODE (final exam, oral defence, report...)	Ratio of the final grade
Supervised project	**30 %**
Final exam	**70 %**

TITLE OF UNIT: Project Design Management

NUMBER of ECTS: 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITES (either in term of skills or knowledge or units to be validated before registration to this course): **scientific and general culture.**

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 6h
Practicals: 10h
Tutorials: 4h

Personal workload (hours expected to be dedicated to, including supervised projects): **55 hours**

Description of the course

General aims

The aim of this course is to provide young scientists the necessary background to highlight the importance of the management in science. It sensitizes young scientists to the central role of project management in their professional careers, and that a science project requires effective management in order to maximize its benefit.

Expected outcomes (knowledge and skills)

The student, at the end of this course, will manage to properly build a scientific project defining clearly the objectives and the relevance of the ideas, making a rational work plan, evaluating the risks and challenges to maximize the chance of success and being able to follow the progress of the project and evaluate the results.

Content summary

Introduction to project management in science
a. Defining science projects
b. Lifecycle of a scientific project

Management of a scientific project
a. Project management processes (project planning and project execution)
b. Concepts and jargon in project management
c. Tools to efficiently manage a scientific project

Person in charge of the unit (first and last name, e-mail)
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Céline TOUBIN, celine.toubin@univ-lille.fr

EVALUATION MODE (final exam, oral defence, report...)	Ratio of the final grade
Ongoing evaluation	**100%**

TITLE OF UNIT : Geoconservation 1 Outreach

NUMBER of ECTS : 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITIES (either in term of skills or knowledge or units to be validated before registration to this course): /.

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 8h
Practicals: 8h
Tutorials: 8h

Personal workload (hours expected to be dedicated to, including supervised projects): **60 hours**

Description of the course

General aims

Geological deposits are the source of major energy, water, mineral and ore. Geological deposits also shape the landscapes and the related biodiversity and ecosystems. As such, they have been significantly influencing the societies (town planning, architecture, human activities), and now constitute important touristic resorts. However, they also represent a major cultural and scientific heritage, for which specific conservation, management and protection are needed. The aim of this unit is to introduce the different types of geological heritage along with their scientific, cultural and touristic potential, and different conservation policies worldwide.

Expected outcomes (knowledge)

At the end of this unit, the student is expected to know the different categories of geoheritage and their specificity.

Expected outcomes (skills)

At the end of this unit, the student is expected to get basic knowledge on how to :
- evaluate the cultural, scientific, heritage potential of a geological site or object;
- evaluate the touristic potential of a geological site;
- identify the level of protection of a site/object, and look for information about its legal status;
- communicate on the geoheritage conservation and its necessity to different audiences.

Content summary

After a brief introduction of the geoheritage concept, the different categories of geological heritage (*in situ, ex situ*, urban, etc) will be presented and illustrated by case-studies from France and abroad.
Special attention will be dedicated to the UNESCO Global Geoparks, and underlying concept of protection, education and sustainability, geotourism. The course will get benefits from the enrollment of international students to present (through supervised project) different approaches, legal protection, conservation of geoheritage in different countries, and different way to evaluate the scientific, cultural, heritage potential of a geological site or object. Some of the national and international NGO's involved in the Geoheritage conservation will be briefly introduced.

Person in charge of the unit (first and last name, e-mail)

Sebastien CLAUSEN
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EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam	**1/4**
Ongoing assessment (case studies)	**1/4**
Supervised project (and oral defense)	**1/2**

TITLE OF UNIT : Geoconservation 2 Geoheritage management

NUMBER of ECTS : 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITES (either in term of skills or knowledge or units to be validated before registration to this course): **Geoconservation 1 – outreach or equivalent.**

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 8h
Practicals: 8h
Tutorials: 8h

Personal workload (hours expected to be dedicated to, including supervised projects): **60 hours**

Description of the course

General aims

Geological deposits are the source of major energy, water, mineral and ore. Geological deposits also shape the landscapes and the related biodiversity and ecosystems. As such, they have been significantly influencing the societies (town planning, architecture, human activities), and now constitute important touristic resorts. However, they also represent a major cultural and scientific heritage, for which specific conservation, management and protection are needed.

This course is a continuation of "Geconservation 1 – outreach". It is aimed at illustrating different strategies and regulations of geoheritage management through different case studies and lectures. Education is central to the concept of geoconservation and geotourism, methods of dissemination will also be introduced by professionals.

Expected outcomes (knowledge)

At the end of the unit, students understand major issues, risk, and impacts related to geoheritage management and promotion.

Expected outcomes (skills)

At the end of the course, students get background knowledge on how to:
- identify cultural and scientific potential of any geoheritage
- prepare leaflets and flyers promoting geosites adapted to target audience
- set up and conduct educational activities related to geosite, collection or any scientific topic
- develop site or exhibition layout

- present a project to decision makers

Content summary

This course is based on presentation, by academics or professional in the field (curators, managers of geosites, natural reserves, geoparks,…) of case studies related to management of geoheritage and promotion of geoturism. Special attention will be given to the inherent difficulties related to the promotion of geoturism, protection of sites or collection, and public accessibility (from scientists to scholars and large audience, including risk); and to the sharing of related good practices. Methods of communication and dissemination, which are inherent to geoconservation (geosite, scientific forums, collections) and geoturism will also be introduced. Students will be placed, as much a possible, at the center of the learning process through workshops, supervised projects based on real cases provided by professionals in the field.

Person in charge of the unit (first and last name, e-mail)

Sebastien CLAUSEN
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EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Ongoing assessment (case studies)	**1/4**
Supervised project (and oral defense)	**3/4**

TITLE OF UNIT : Palaeoclimatology

NUMBER of ECTS : 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITES (either in term of skills or knowledge or units to be validated before registration to this course): /.

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures: 6 h
Practicals: 6 h
Tutorials: 6 h

Personal workload (hours expected to be dedicated to, including supervised projects): **40 hours**

Description of the course

General aims

The study of climate change at different time scales (tectonic, orbital, millennial, decadal): the course reviews the forcing mechanisms and interactions of the climate system, the contribution made by numerical climate models. Issues related to modelling are also discussed. Examples of paleoclimatic reconstructions are given from the Paleozoic, Cretaceous, Cenozoïc, Quaternaty and Holocene based on environmental records (marine sediments, lake sediments, glacial record, speleothemes, etc.).

Expected outcomes (knowledge)

At the end of the unit, students will have good knowledge of
- Main environmental proxies
- Main paaleoclimatie archives
- Climate changes through Earth History and today
- Main processes forcing climate change over different time scales
- Principles of climate modeling.

Expected outcomes (skills)

At the end of the unit, students will have good knowledge of how to:
- analyze and interpret the information from main paleoclimate archives (proxies)
- contextualize (spatially and temporally), rank and combine proxies used to understand the climate and its change
- distinguish between established knowledge and hypotheses to be tested

- identify the main current issues in palaeoclimatology
- understand the issues and challenges of the numerical modeling.

Content summary

- Paleoclimate reconstruction over different time scales (Palaeozoic Cretaceous, Cenozoic, Quaternary, Holocene) using environmental archives such as marine sediments, lacustrine sediments, glacial record, speleothems...)
- Processes triggering the evolution of climate at all-time scales (tectonic, orbital, millenial-scale, decade-scale)
- Climate system components and their interaction
- Contribution of numerical modelling to the understanding of past and future climate change

Person in charge of the unit (first and last name, e-mail)

Aloys Bory
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EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam and/or report	**100%**

TITLE OF MODULE: Palaeoenvironmental reconstructions 2

NUMBER of ECTS : 3

OPTIONAL or COMPULSORY (if applicable): **Compulsory**

PREREQUISITES (either in term of skills or knowledge or units to be validated before registration to this course): **Micropalaeontology, Sequence stratigraphy.**

MODE OF TEACHING (distance education, webinar, workshops, seminars, lectures, supervised projects, etc): **lectures, tutorials, practicals.**

Number of hours dedicated to lectures, practicals, field-excursions, etc:
Lectures:6 h
Practicals: 6 h
Tutorials: 6h

Personal workload (hours expected to be dedicated to, including supervised projects): **40 hours**

Description of the course

General aims

The objective of this module consists in learning how to use microfossils to reconstruct marine or terrestrial paleoenvironments useful for deciphering sea-level changes, basin analysis and geoarcheological issues.

Expected outcomes (knowledge & skills)

The student will be familiarized with the methods that allow microfossils to be used for sequence stratigraphic analyses and for understanding the thermal maturity of sediments. Each systems tract has potentially a distinctive assemblage of microfossils and the student will be familiarized with all possible cases. Some micropalaeontological groups (spores and pollen, diatoms, ostracods) found in fluvial, lacustrine or cave sediments may provide valuable palaeoenvironmental information for prehistoric or archeological studies.

Content summary

This module will illustrate the key role played by microfossils in sequence stratigraphic and basin analyses, as well geoarcheological studies. The capacity to identify specific taxonomic groups (e.g. porcelaneous *vs* hyaline benthic foraminifera, algae) may provide specific evidence for palaeobathymetric and hydrodynamic reconstructions and/or discrimination of marine *vs* terrestrial environments. This kind of palaeoenvironmental information, built in a basin-wide spatiotemporal framework (vertical and horizontal distribution of facies in a well constrained time framework) is of great value for basin analysis, as it may allow to decipher if a basin margin is prograding/retrograding/aggrading. Palynological assemblages of terrestrial origin may provide evidence for changes on the land mass adjacent to the basin and direct evidence for the relationship between the past local vegetation and the composition of organic matter preserved

in sediments. The color hue of some microfossils (conodonts, palynological/organic remains) may be used as geothermometers and will provide complementary useful information for application in hydrocarbon exploration.

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EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam	**70%**
Ongoing assessment	**30%**