



MASTER BIODIVERSITY, ECOLOGY AND EVOLUTION

MASTER 1 & 2

Program

**SYSTEMATIC, EVOLUTION AND
PALEONTOLOGY**



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DEGREE TITLE: Biodiversity, Ecology, and Evolution**PROGRAM:** Systematics, Evolution, Paleontology**SPECIALIZATION:** All**Title of the module:** Phylogenetic Reconstruction: Techniques and Uses (ADAPHYL)**Coordinators:** Yves Desdevises, Sophie Sanchez-Brosseau**Organization of the module:**

Semester	ECTS	CM (h)	TD (h)	TP (h)	Nb of weeks	Hours per week	Maximum participants
M1-S2	6	20	37	3	2	30	25

Objectives of the module:

Review of phylogenetic reconstruction concepts and techniques, and introduction to the applications of phylogenies: comparative phylogenetic methods, molecular dating, reconstruction of ancestral characters, cophylogeny. Through the study of a family of teleosts and data retrieved from online databases, students will construct phylogenies to test different hypotheses using the methods presented.

This teaching in blended-learning mode with Moodle. Distance learning: video courses, interview, quiz, papers reading, synthesis exercise. Presential: data collection; computer work; conferences; article analysis; personal project.

Key words:

Phylogenetic reconstruction, Evolutionary model selection, Phylogenetic comparative method, Molecular dating, Cophylogeny, Software

Target skills:

Choose and implement a phylogenetic reconstruction method
Explore online molecular databases
Use different approaches to study evolutionary patterns and processes
Define a scientific question and the steps to answer it

Pre-requisites:

Basic knowledge of biology, evolutionary biology and statistics

Evaluation:

Oral presentations in pairs: article analysis (oral) and personal project (cont.) (case study)

Evaluation criteria: mastering of concepts, rigour in the scientific approach, clarity in the presentation of results

Evaluation procedure and scoring: Written, Practical., Continuous Assessment, Oral

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systematics, Evolution, Paleontology

SPECIALIZATION: All

Title of the module: Databasing – data models – data query

Coordinator(s):

Régine VIGNES LEBBE

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
M1 S2	3	8	14				

Objectives of the module:

Databases are the essential tools to model, to store and to manage data. This course brings the theoretical and practical knowledge of databasing. Database Management Systems are now easily accessible and any young naturalist, researcher and environmental manager, will find in the use of these software and query language, powerful methods of structuring and analyzing data.

Key words:

Database management system, SQL, relational model, entity-relationship model

Target skills:

Students are then able to implement a database, from data modelling to database development and use.

Principles end steps of databasing

Modelling languages (entity-association conceptual model, UML)

Relational database: model, query language SQL, constraints.

Data quality and International standards for the exchange of biodiversity data.

Pre-requisites:

No

Evaluation:

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral and personal project

Contact(s):

Régine VIGNES LEBBE : regine.vignes_lebbe@sorbonne-universite.fr

DEGREE TITLE: Biodiversity, Ecology, and Evolution**PROGRAM:** Systematics, Evolution, Paleontology**SPECIALIZATION:** All**Title of the module:** From the field data to laboratory analysis in paleontology**Coordinator:** Isabelle Rouget**Organization of the module:**

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number Of Weeks	hours per week	Maximum participants
M1-S2	3	3		27	1	30	10

Objectives of the module:

The aim of this teaching unit is to conduct a research project on paleobiodiversity from the fieldwork to quantitative analyses. During the process, all practical steps are implemented: geological surveys in the field, establishment of a sampling protocol, laboratory processing (mechanical or chemical extraction, sifting, washing, sorting, identification, species illustration). At each stage, the impact of technical choices on paleobiodiversity measurements and estimates is discussed. The analytical tools are chosen according to fossils under study and to the scientific questioning. Sampling is done at Grignon (Yvelines) which is a paleontological site in the Paris Basin considered as a biodiversity hotspot in Lutetian. Sediments allow an easy and thorough study of ecosystems and a very large diversity of taxa sampling.

Key words:

Fieldwork, sampling, sample preparation, identification, palaeobiodiversity.

Target skills:

Be able to carry out a study of paleobiodiversity from the field to data processing, limiting sampling and methodological bias.

Pre-requisites:

No prerequisite.

Evaluation:

Report including fieldwork and results from the paleobiodiversity analyses.

Contact(s):

Isabelle Rouget : Isabelle.rouget@mnhn.fr

DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systématique, Evolution, Paléontologie

SPECIALIZATION: All

Title of the module: Taxonomic identification methods

Coordinator(s):

Régine VIGNES LEBBE

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
M1-S2	3	8	14				

Objectives of the module:

This course presents the different methods and types of characters used for taxonomic identification:

Computer aided identification keys, how to use Xper3 platform

Barcoding,

Metabarcoding

Morphometry

Acoustic

Image analysis, new artificial intelligence methods (deep learning)

How to identify in paleontology

Identification needs and citizen science

A large part of the course is dedicated to practical use. At the end, the students produce and publish online a digitized key using the Xper3 platform (<http://www.xper3.fr/?language=en>).

Key words:

Identification, key, barcoding, acoustic data

Target skills:

Autonomy to use the different identification methods.

Computer aided identification keys for single access keys and free access keys.

Pre-requisites:

No

Evaluation:

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral and personal project

Contact(s):

Régine VIGNES LEBBE : regine.vignes_lebbe@sorbonne-universite.fr

DEGREE TITLE: Biodiversity, Ecology and Evolution

PROGRAM : Systématique, Evolution, Paléontologie

SPECIALIZATION: all / BEVT

Title of the module: Anatomico-morphological diversity and green lineage history - DIVEG

Coordinator(s): D. De Franceschi & J.-Y. Dubuisson

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Nb of weeks	Hours per week	Maximum participants
M2-S3	6	36	3	21	2	30	25

Objectives of the modules:

This EU proposes to specify, in a historical and evolutionary framework, the organization of the main «algae» phyla, terrestrial plants (Embryophytes) and the key events that characterized this evolution. Within an epistemological framework, the different classifications (artificial systems, traditional natural classifications, gradist or cladistic) will be exposed and compared. The practical training will include the research of homologies, the characterization of the different organs, the different identification methods of green lineage organisms and the floristic bases.

Key words:

Cyanobacteria – « algae » - endosymbiosis - ovule - Embryophytes - Monilophytes - Spermatophytes - floristic - angiospermes – floral analysis

Target skills:

Acquiring the basic knowledge of current and fossil large plant groups, the diversity of their organisational schemes, the criteria and methods used for systematic grouping.

Pre requisites:

No prerequisites, but basic knowledge in plant biology is recommended.

Evaluation :

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral

Contact(s):

Dario De Franceschi : dario.de-franceschi@mnhn.fr

Jean-Yves Dubuisson : dubuisson@mnhn.fr

DEGREE TITLE : Biodiversité, Ecologie et Evolution

PROGRAM : Systématique, Evolution, Paléontologie

SPECIALIZATION : all

Title of the module :

Exploration and Description of Biodiversity

Coordinator(s) : Nicolas Puillandre & Philippe Bouchet

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Nb of weeks	Hours per week	Maximum participants
M2-S3	3	25		7	1	32	20

Objectives of the module:

The debate is raging in the scientific community and throughout society on the future of biodiversity. But where are we standing with regard to the

The debate is raging in the scientific community and throughout society on the future of biodiversity. But where are we standing with regard to the inventory of species of animals, fungi and plants on the planet? What remains to be discovered, and where? Where and how are the descriptions of new species published? What do systematists do during the "6th extinction"? Has the rise of molecular approaches in taxonomy changed the situation?

The course will consist of lectures on general natural history culture and a day of practical work on a computer.

Key words:

Naturalistic expedition, species, biodiversity crisis, integrative taxonomy, description.

Target skills:

Acquire knowledge on issues related to the exploration, description and referencing of biodiversity, in the current context of extinction crisis; apply species delimitation methods and acquire basic knowledge on the work of the systematists.

Pre-requisites:

No

Evaluation:

A personal work is asked to each student, on a topic discussed and agreed during the course module. This subject is intended to develop his/her reflection on the practices and attitudes in the profession of systematics.

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systematics, Evolution, Palaeontology

SPECIALIZATION: All

Title of the module:

Formalisation of knowledge in Systematics and Three-item analysis

Coordinator(s):

René Zaragueta et Régine Vignes-Lebbe

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
M2-S3	3	15	15	-	1	30	∞

Objectives of the module:

Formal description of knowledge underlies methodological approaches. Our course introduces the mathematical and logical objects through which the main concepts of systematics theory, and of the main phylogenetic methods, are described.

The program illustrates the theoretical and methodological application of formalisation of knowledge in phylogenetics by the three-item analysis interpretation of cladistics.

Key words:

Formalisation, model, computer representation, character, homology, three-item analysis, cladistics

Target skills:

Formal basics allowing formal abstraction and mathematical representation of a wide range of scientific problems.

Aptitude of abstraction of a particular scientific problem into an formal class of problems.

Synthesis capacity.

Ability to argue theoretical and methodological choices.

Pre-requisites:

Basics of biology and phylogenetic concepts.

Evaluation:

Written and oral presentation of a personal work on bibliographical analysis of at least 2 scientific papers. Students are given a wide choice of couples of papers, each addressing a particular aspect of the course.

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral

Contact(s):

René Zaragueta :
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Régine Vignes-Lebbe :
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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systematics, Evolution, Palaeontology

SPECIALIZATION: all

Title of module: Taxinomy & Nomenclature

Coordinator: Annemarie OHLER

Organization of the module:

Semestre	ECTS	CM (h)	TD (h)	TP (h)	Nb of weeks	Hours per week	Maximum participants
M2-S3	3	24		6	1	30	20

Objectives of the module:

The module Taxinomy & Nomenclature will provide an outline of the problems created by the naming of taxons and the introduction of the names into a system, by applying methodological and conceptual frames that are in permanent evolution. The solutions proposed by the zoological and botanical nomenclature, by the phylocode, as well as by present relaxions on nomenclatural systems are presented. The goal is to understand and to apply the proposed rules in the existant systems and to show the various answers to the questions and problems encounterd in this domain.

Key words:

Taxinomy, nomenclature, zoology, botany, codes

Target skills:

Understand and apply the rules of the existant codes, understand the concepts regulating these codes, in order to be capable to apply these contents to nomenclatural cases encountered during the own systematic research.

Pre-requisites:

Interest in systematics and logics.

Evaluation:

Written examen on content of the lectures and practical exercise.

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral

Contact(s):

Annemarie OHLER
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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systematics, Evolution, Palaeontology

SPECIALIZATION: all

Title of the module: Principles and methods in Taphonomy

Coordinator(s): Ronan Allain , Marylène Patou-Mathis & Stéphane Péan

Organization

Semester	ECTS	CM (h)	TD/TP (h)	Number of Weeks	Hours per week	Maximum participants
M2-S3	3	15	1/4	2	20	25

Objectives

Understand the principles and methods of taphonomy in paleontology and archaeology.

Key words

Fossilization - Diagenesis - Alteration – Bone modification - Paleontological and archaeological sites

Target skills

Be able at the end of the unit to design a research project including a taphonomical study and apply the methods.

Prerequisites

if possible have a background in comparative anatomy

Evaluation procedure

written exam 3h, oral re-take exam if needed

Written Practical Continuous Assessment Oral

Contact(s)

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systematics, Evolution, Palaeontology

SPECIALIZATION: all

Title of the module: Morphometrics and Shape Analysis

Coordinator(s):

Sylvain GERBER (MC ISYEB)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Nb of weeks	Hours per week	Maximum participants
M2-S3	3	10	10	10	1	30	20

Objectives of the module:

The goal of the course is to provide students with a general overview of the concepts and methods of shape analysis in biology (traditional and geometric morphometrics in both 2D and 3D), and to illustrate the diverse applications of morphometrics in life sciences (systematics, ecology, and evolution). The course includes lectures and hands-on applications for which students collect morphological data and explore the dataset constructed with various morphometric tools.

Key words:

morphometrics, phenotype, shape, size, allometry, landmarks, outlines, morphospace

Target skills:

Understanding of the aims and principles of morphometrics. Knowledge of the diversity of morphometric descriptors, and of their strengths and weaknesses. Ability to conduct a morphometric study: choice of descriptors, data acquisition, exploration and visualization, critical discussion of results

Pre-requisites:

Some knowledge of multivariate statistics and of the R environment can be useful.

Evaluation:

Grading consists in an oral presentation(PowerPoint) of the work done during the practicals.

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systematics, Evolution, Palaeontology

SPECIALIZATION: All, Palaeontology

Title of the module:

Palaeo-Biogeography and Palaeo-Biodiversity

Coordinator(s):

Loïc Villier, PR, SU et R. Zaragüeta, MCU, SU

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
M2-S3	3	15	15		2	15	-

Objectives of the module:

The course focuses on two main goals.

First, understand the theoretical and methodological principles used in biogeography studies by both biologists and palaeontologists. The comparative tools and the reconstitution of the geographical history of taxa and areas (similarity index of taxonomic associations, historical approaches, cladistic methods...) are the main points addressed.

The distribution of biodiversity on the surface of the globe and its history are intimately linked to the history of physical geography and the ecology of species.

The second objective is to illustrate this relationship (endemism, surface/biodiversity relationship, influence of the conformation of continents and environmental conditions, etc.) through examples of continental or marine organisms.

Key words:

biogeography, biodiversity, phylogenetics, palaeontology, continental and oceanic environments

Target skills:

Knowledge of concepts and methods of analysis of biogeography. Integration of palaeo-biogeography into current and fossil biodiversity models.

Pre-requisites:

Minimum knowledge (Grade level) in biodiversity, phylogenetics, and plate tectonics.

Evaluation:

2h written exam

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral

Contact(s):

Loïc Villier, Sorbonne Université, Centre de Recherche sur la Paléobiodiversité et les Paléo-environnements, UMR 7207, Tour 46-56, 5e étage, case 104, 4 place Jussieu, 75252 Paris Cedex 05

DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systematics, Evolution, Palaeontology

SPECIALIZATION: all

Title of the module: Paleohistology

Coordinator(s):

Jorge CUBO

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Nb of weeks	Hours per week	Maximum participants
M2-S3	3	15	15		2	15	25

Objectives of the module:

To perform paleobiological inferences of lifestyle, metabolic rate, growth rate, locomotion type, etc, in extinct vertebrates using bone paleohistology and the phylogenetic comparative method. To infer life-history traits, growth and developmental strategies, paleoenvironmental parameters, etc. To synthesize structure-function relationships of skeletal tissues in extant and extinct vertebrates and their evolution.

Key words:

Paleobiology, lifestyle, metabolic rate, growth rate, locomotion, bone paleohistology, phylogenetic comparative method, life-history traits, growth strategies, developmental strategies, paleoenvironments, skeletal tissues, vertebrates.

Target skills:

To perform paleobiological inferences using bone paleohistology and the phylogenetic comparative method.

Pre-requisites:

Notions in phylogeny and in vertebrate biodiversity

Evaluation:

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral

Contact(s) :

Jorge Cubo
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Centre de Recherche en Paléontologie – Paris (UMR
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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systématique, Evolution, Paléontologie

SPECIALIZATION: All

Title of the module:

Fossils contribution in the phylogeny of the major clades of Metazoans

Coordinator: Olivier Béthoux

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
M2-S3	3	27	3		1	30	20

Objectives of the module:

The aim of the course is to provide the knowledge and tools necessary for the use of factorial analysis and other approaches of multivariate data analysis. The

This module tackles the systematics and evolutionary history of the major clades of metazoans in the light of the fossil record, with a focus on associated morphological characters. This goal is achieved by the study of selected fossil cases which had a key role in phylogenetic reconstruction and/or the temporal calibration of these relationships. When relevant, the discovery of the importance of these fossils is brought into historical scientific context. Selected cases cover the different levels of phylogenetic inference fossils can impact, namely topological homology, and primary & secondary homology

Key words:

Paléontologie, comparative anatomy, homology, phylogeny, key fossil, Metazoa, Vertebrata, Echinodermata, Mollusca, Arthropoda

Target skills:

Acquisition of general knowledge on:

- characters of the major clades of metazoans and their timing of appearance;
- the identification of characterization of a key fossil. Acquisition of specific knowledge on:
character systems commonly used in comparative anatomy applied to fossil metazoans.

Pre-requisites:

Good notions of animal systematics, basics in phylogenetic inference.

Evaluation:

Evaluation procedure and scoring: Written (3h), Practical, Continuous Assessment, Oral

Contact(s):

Olivier Béthoux : obethoux@mnhn.fr

DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systématique, Evolution, Paléontologie

SPECIALIZATION: All

Title of the module:

Multivariate statistics and data analysis

Coordinator: Sandrine Pavoine, Associate Professor MNHN

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
M2-S3	3	18.5	10.5		1	29	20

Objectives of the module:

The aim of the course is to provide the knowledge and tools necessary for the use of factorial analysis and other approaches of multivariate data analysis. The course includes an introduction to R software, a graphical and statistical environment widely used in research and freely available on most computer platforms. It will be illustrated with numerous examples.

Key words:

Multivariate statistics, principal component analysis, correspondence analysis, multiple correspondence analysis, discriminant analysis, hierarchical clustering, partitions, Gaussian mixtures, analysis of distance matrix, Mantel test, R language

Target skills:

Master the various analysis techniques, select the methods adapted to the data, produce appropriate and quality graphics, summarize the results for publication, master the ad hoc functions of R.

Pre-requisites:

Basic statistical concepts such as variance, covariance, correlation

Evaluation:

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral analysis of a new dataset, report in the form of slides and oral defense)

Contact(s):

Sandrine Pavoine : sandrine.pavoine@mnhn.fr

DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systématique, Evolution, Paléontologie

SPECIALIZATION: All

Title of the Module: Metazoan phylogeny and the evolution of animal body plans

Coordinator: Michaël Manuel (michael.manuel@upmc.fr)

Organization of the module:

Semestre	ECTS	CM (h)	TD (h)	TP (h)	Nb de semaines	Nb heures par semaine	Effectifs maximum
M2-S3	3	9	11	10	1	30	20

Objectives of the module:

This teaching unit addresses the diversity and evolution of metazoans (multicellular animals) at a wide taxonomic scale, by considering data from phylogenetic studies, comparative anatomy, comparative genomics, embryology and evo-devo. Contents: (i) Historical aspects (*lecture*); (ii) Critical synthesis of recent research about metazoan phylogeny and evolution (*lecture*); (iii) *Thematic tutorial sessions*: Evolution of body cavities; Inputs from evo-devo research; Inputs from the study of Ediacaran and Cambrian fossils; (iv) The so-called “minor phyla” and their importance in understanding the evolution of key anatomical features (*practicum*).

Key words:

Body plan, comparative anatomy, embryology, evolution, evo-devo, metazoans, phylogeny.

Target skills:

Grasping morphological diversity ; observing, describing and comparing the anatomy of an organism.
Understanding fundamental concepts: their definition, historical dimension, and empirical applications.
Optimising characters onto a phylogeny.
Discussing research results (methodological choices and limitations; interpretations ...).

Pre-requisites:

Bachelor-level knowledge about morpho-anatomical organisation of the major metazoan phyla (summary documents supplied upon registration).

Evaluation:

Evaluation procedure and scoring: Written (1ère session), Practical, Continuous Assessment, Oral (2ème session)

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: Systématique, Evolution, Paléontologie

SPECIALIZATION: All

Title of the module: Origins of Life (UE hors contrat pédagogique)

Coordinator : Marie-Christine Maurel

Organization of the module:

Semestre	ECTS	CM (h)	TD (h)	TP (h)	Nb de semaines	Nb heures par semaine	Effectifs maximum
M2-S3	3	15	15	0	1	30	20

Objectives of the module:

Initiation at M2 level to themes related to the Origins of Life in the Solar System and beyond (exoplanets). The objectives are to ensure a basic scientific culture, a good level and a critical look at these subjects in relation to very current issues on synthetic biology, the origin and importance of photosynthesis in problems related to the environment and ecology, GMOs, xenobiology, etc.. Manipulate, manufacture life? Is it possible? Is it desirable? Planetology and space exploration will also be presented in the environmental context.

Key words:

Origins of life, synthetic biology, xenobiology, photosynthesis and environment, GMOs, making life, solar system, Mars.

Target skills:

Be able to carry out a study of paleobiodiversity from the field to data processing, limiting sampling and methodological bias.

Pre-requisites:

Strong motivation and an acute scientific curiosity to acquire solid knowledge on topics little covered in "classical" curricula.

Evaluation:

Evaluation by means of a continuous written test and an oral presentation of article analysis.

Evaluation procedure and scoring: Written, Practical, Continuous Assessment, Oral

Contact(s) :

Marie-Christine Maurel : marie-christine.maurel@mnhn.fr et marie-christine.maurel@sorbonne-universite.fr ISYEB - Institut de Systématique, Evolution, Biodiversité (UMR 7205, MNHN, UPMC, CNRS, EPHE) 45 rue Buffon 75005 Paris

