SYLLABUS - FIRST SEMESTER (M1S1)

Master Biodiversity, Ecology and Evolution

International Pathway "Evolutionary Biology"

TITLE OF UNIT: Evolutionary Biology and Population, Communities and Networks Dynamics

NUMBER of ECTS: 9

1-Evolutionary Biology (Jean-François Arnaud, Professor)

Number of hours: **Lectures: 15h**, **Practicals: 18h**, **Tutorials: 8h**
Personal workload (hours expected to be dedicated to, including supervised projects): **67 hours**

Description of the module

General aims

The EC entitled « Evolutionary Biology » provides an entry to the dynamic field of studies of evolution for undergraduates majoring in the life sciences. The EC's aim at providing a good understanding of microevolutionary processes and their consequences in various field of research such as behavioural ecology or the evolution of gene frequencies in space and time. Ecological consequences are highlighted in the EC named « Population dynamics ».

Content summary

The EC provide basic and more advanced knowledges on key concepts related to the neo-Darwinian synthesis, to the evolution of populations with finite sizes, to the estimation of patterns of gene flow within and among populations located in fragmented habitats, to the action of natural selection leading to adaptive evolution, to the evolution of quantitative characters through phenotypic plasticity, to the cost of sex and/or to kin selection relying on genetic relatedness among individuals. Therefore, the undergraduates will be expected to get fundamental theoretical knowledges and applied skills in evolutionary biology.

Expected knowledge and skills

- Describing and predicting the genetic and genotypic structure under various models of populations in disequilibrium.
- Analysing the genetic relatedness and the inbreeding coefficient.
- Estimating the levels of genetic differentiation among populations and interpreting the results in terms of patterns of gene flow.
- Estimating the effective population size through direct and indirect methods.
- Understanding the societal impact of studying neutral and adaptive microevolutionary forces and linking science with practice to protect the biodiversity.
- Additional skills: setting up an experimental design, writing a scientific report, performing phenotypic measures in the field, programming and statistically analysing empirical data using R.

2-Population, communities and networks dynamics (Sylvain Billiard, Associate Professor)

Number of hours: **Lectures: 20h, Practicals: 12h, Tutorials: 8h**
Personal workload (hours expected to be dedicated to, including supervised projects): **68 hours**

Description of the module

General aims

There are two main objectives:

1- Be able to decipher and understand the ecological mechanisms underlying the variation in population and communities' sizes, and in ecological networks organization: the role of space, intraspecific and interspecific interactions, the

different time scales, the importance of stochasticity. Much effort will be devoted to describing and understanding a large variety of methods and approaches, both experimental and theoretical.

2- Learn how to estimate populations and communities'sizes and their variation, and use that information for ecosystem management purposes: population viability analysis, ecosystem services protection, measuring the effect of anthropogenic disturbance on biodiversity

Content summary

- Role of intraspecific and interspecific interactions for populations and communities' dynamics (competition, mutualism, predation)
- Role of chance (Neutral theory of biodiversity)
- Dynamics of communities in space and metacommunities
- Ecological networks and communities' stability
- Methods for estimating population sizes and ecological parameters (death and birth rates, dispersal rates, transition rates)
- Population viability analyses: methods and robustness assessment
- The relationship between biodiversity and ecosystem services
- Evolutionary vs. ecological timescales

Expected knowledge and skills

- Deciphering mechanisms underlying the evolution of ecological systems
- Applying experimental and modeling methods to address ecological questions
- Comparing and choosing solutions for ecosystems and natural resources management
- Master informatic tools for addressing ecological questions and problems
- Understanding, developing and using adapted tools to address multidimensional problems
- Searching solutions on their own in various resources: literature, software, internet
- Handling informatics tools for data analysis, modeling and problem solving

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

TITLE OF UNIT: Conservation Genetics (Xavier Vekemans, Professor)

NUMBER of ECTS: 3

Number of hours: **Lectures: 11h, Practicals: 6h, Tutorials: 10h**

Personal workload (hours expected to be dedicated to, including supervised projects): **45 hours**

Description of the module

General aims

To understand the concepts of ecology, evolutionary biology, and evolutionary genomics on which conservation genetics is based. To become familiar with the methodological approaches used for the estimation of intraspecific biodiversity, and for the conservation of threatened species. To analyze and contextualize the results of a conservation biology publication.

Content summary

Introduction to Conservation Biology and Conservation Genetics: objectives of the field of conservation biology; descriptors of the organization of intraspecific biodiversity; genetic and demographic causes of extinction; presentation of conservation methods. Application with the analysis of data sets during practical work. Analysis of the results of a conservation biology publication and oral presentation.

Expected knowledge and skills

- Be able to make an inventory of the strategic choices to be made for the implementation of a conservation program, and use decision-making tools to guide these choices
- Use objective criteria to determine the level of threat to a species.
- Additional and transversal skills: data analysis with R, understanding a scientific article in English; critical analysis of an article; oral presentation.

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam (written exam)	**70%**
Ongoing assessment (Analysis of a scientific publication and oral presentation)	**30%**

TITLE OF UNIT: Introduction to Omics Data (Céline Poux, Associate Professor)

NUMBER of ECTS: 3
Number of hours: **Lectures: 20h**, **Tutorials: 7h**
Personal workload (hours expected to be dedicated to, including supervised projects): **45 hours**

Description of the module

General aims
- To develop and mobilize knowledge concerning the different types of OMICS data (genomic, transcriptomic, proteomic and lipidomic data), their acquisition and some of their applications, particularly in precision medicine.
- To gain a better understanding of the results of OMICS data analysis in further training and/or in a professional context.
- To develop students' critical thinking skills when reading scientific articles regarding OMICS data acquisition.

Content summary
- General Introduction to Genetics and Genomics
- Introduction to OMICS data: DNA and RNA sequencing (Sanger, the different generations of NGS), sequencing data (from machine output to sequence data), applications of sequencing data to theoretical and/or applied scientific questions. Introduction to proteomics and lipidomics data acquisition.
- Use of OMICS data in human health: monogenic/polygenic diseases and precision medicine (GWAS and post-GWAS, large scale NGS DNA sequencing, microarrays, RNA-seq, proteomics)

Expected knowledge and skills
- Understanding the different types of DNA/RNA sequencing
- Knowing the applications of sequencing
- Knowing how to manipulate sequencing data
- Knowing how to use sequencing data for precision medicine
- Knowing the basics of proteomics and lipidomics

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

TITLE OF UNIT: Informatics tools for Biologists (Sébastien Grec, Associate Professor)

NUMBER of ECTS: 3
practicals.
Number of hours: **Tutorials: 24h**
Personal workload (hours expected to be dedicated to, including supervised projects): **48 hours**

Description of the module

General aims
The objective of the module is to acquire computer skills allowing the processing of file data coming from high-speed analysis tools. For this, three levels of learning are offered:
1) Learn Unix commands and understand the interest of scripts to automate tasks, acquire the basics of bash shell scripting.
2) Acquire bases of a algorithm and programming language: python
3) Introduce python module dedicated to Bioinformatic analysis: Biopython.
The teaching is done by alternating theoretical and practical parts using open-source numeric tools.

Content summary
- Introduction to Unix system and command line
- The Bash language for handling and managing files
- Introduction to bash command lines
- Write a Bash script to automate file management
- Extract file information using Grep and Hawk functions
- Introduction to python language
- Understand what a programming language is
- Python's place in the programming field
- Bases of python programming: Data and variables, operators, input / output, control structures, list and dictionaries, iterative loops, reading and writing files
- Create scripts for handling biological and genomic data
- Introduction to Bio-Python language
- Manipulation of genomic data with Biopython
- Introducing bio python in genomic analysis pipeline

Expected knowledge and skills:
- Understanding and navigating into a unix system
- Manipulating files and folders
- Seeking informations into files
- Scripting commands
- Be familiar with the notion of algorithm
- Being able to write a script to manipulate data
- Data manipulation with automated approaches
- To realize a simple code in bio-python language

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam (consists in carrying out a final task according to a specification by reinvesting the tools acquired during the training. The project report will be accompanied by an oral presentation)	**70%**
Ongoing assessment (consists of subject knowledge checks during the course sessions)	**30%**

TITLE OF UNIT: Statistics Initiation with R (Sylvain Billiard, Associate Professor)

NUMBER of ECTS: 3
Number of hours: **Practicals: 24h**
Personal workload (hours expected to be dedicated to, including supervised projects): **48 hours**

Description of the module

General aims
To introduce the students to the use of an open and generalist software commonly used in ecology. The students will be taught to use R to analyze data, perform advanced statistical testings, program, files management and figures creation. This teaching is a prerequisite for other EC and UEs in the Graduate Program. Students will be taught the basics of data analyses and statistical testing: the different statistical frameworks, their hypotheses and their applications.

Content summary
1 – R basics: script, package, functions, calculations
2 – Formatting and reading datasets
3 – Programming basics: loops, logical tests, definition and use of functions
4 – Creation and exportation of figures

5 – Basics: Probabilities, distributions, independence, summary statistics, definition of a statistical test, definition of p-values and the different types of errors.
6 – Introduction to statistical testings with non-parametric models: Chi2 and exact tests
7 – Introduction to statistical testings with parametric models: linear models and non-linear models
8 – Application to ecological and evolutionary data

Expected knowledge and skills
Direct abilities:
- Exploit a software for data management and analysis, and programming
- Programming with R
- Figures
- Deciding how to analyze data
- Formulating hypotheses and interpreting results
- Verifying statistical tests quality and evaluating confidence level of the analysis

Indirect abilities:
- Algorithms and programming
- Informatics
- Introduction to data analysis and statistical testings
- Communicating methods and results
- Searching literature and internet resources to achieve a specific goal

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam (data analysis with R on computers, evaluation of a written report)	**75%**
Ongoing assessment (realization of a programming project on R on computers, evaluation of the product)	**25%**

TITLE OF UNIT: Scientific Writing and Communication (Céline Toubin, Graduate Programme)

NUMBER of ECTS: 3
Number of hours: **Lectures: 10h, Practicals: 10h**
Personal workload (hours expected to be dedicated to, including supervised projects): **52 hours**

Description of the module

General aims and content summary
This teaching is designed to train students for
- The search for information in the scientific literature,
- The implementation of automated monitoring strategies,
- Evaluation of the quality and relevance of the information found,
- The organization and archiving for reuse.

It will also involve training students in publishing practices (peer review, publishing house, open archives, etc.), bibliometrics, as well as the associated ethical rules (plagiarism, identification of co-authors, etc.). In addition, students will be taught how to develop their capacity to write a scientific article or report, to help them decide on the best way to present their results, to target the right type of publication and to be able to communicate their results to different types of audiences (article, poster, slide show...).
The module will be complemented by an introduction to rhetoric to stimulate students' argumentation skills.

Expected knowledge and skills
The learner will become familiar with writing and communication techniques, which will enable him/her to develop analytical and synthesis skills in order to maximize his/her chances of communicating his/her results to different audiences (peers, general public).

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Full ongoing assessment	**100%**

TITLE OF UNIT: Language

1-English (Jean-François Arnaud, Professor) - Optional

NUMBER of ECTS: 3
Number of hours: **Tutorials: 20h**
Personal workload (hours expected to be dedicated to, including supervised projects): **52 hours**

Description of the module
General aims

Content summary

Expected knowledge and skills

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam	**50%**
Ongoing assessment	**50%**

2-FLE : Français Langue étrangère - Optional

TITLE OF UNIT: Student project – Projet de l'étudiant (PE)

1- Geobiosphere interactions in deep time (Taniel Danelian, Professor) - Optional

NUMBER of ECTS: 3
Number of hours: **Lectures: 6h**, **Practicals: 6h**, **Tutorials: 8h**
Personal workload (hours expected to be dedicated to, including supervised projects): **52 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.

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