

DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES20 - Microbial diversity and their functional ecology (ES20/MU5BM618/BIODIV)

Start date: September End date: September

Coordinator(s): Isabelle Florent (MNHN) & Julie Leloup (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	6	48	6	6	2	30	18 including 9 SU

Objectives of the module:

The objectives of this teaching unit are to present a global vision of microorganisms at the taxonomic, structural and ecological levels: archaea, bacteria, cyanobacteria and large eukaryotic phyla (e.g. protists, fungi). The course is organised into thematic days around the different taxonomical groups of organisms, with a focus on their biodiversity as well as their interactions with the different compartments of the living and their roles in ecosystem functioning and bio-geochemical cycles at different scales.

Key words:

Microbial diversity, eukaryotes and prokaryotes, taxonomy, aquatic and terrestrial environments. "Scientific analysis" teaching unit.

Target skills:

Global vision of the diversity of microorganisms, notions of taxonomy.
Distribution of microorganisms in ecosystems, biotic and abiotic interactions.

Pre-requisites:

Biology of organisms, major domains of the Tree of Life, cell biology, prokaryotes, eukaryotes, notions on ecosystems.

Evaluation:

Date of the evaluation: M2S3 (December)

Evaluation procedure and scoring: x Written (40%), Practical, Continuous Assessment, x Oral (60%)

At the beginning of the course, students will choose a scientific theme (analysis of 3 articles), presented or not during the conferences, and will have to produce a synthesis of these works, which will be presented orally (60 points). A written exam will complete the knowledge test procedures (40 points).

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES21 - Characterization, role and valorisation of microbial molecules (ES21/MU5BM611/MOLMIC)

Start date: October - November

End date: October - November

Coordinator(s): Soizic Prado (MNHN) & Séverine Zirah (MNHN)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	6	48	12	0	2	30	20

Objectives of the module:

This teaching unit is devoted to microbial natural products, their roles in ecosystems and the structural analysis methods to identify these molecules. Their environmental and/or therapeutic applications will be presented.

Key words:

Natural product chemistry, specialized metabolites, chemical ecology, valorization, spectroscopic methods (NMR, mass spectrometry).

Target skills:

Microbial molecules : diversity and applications.

Methods for the discovery, isolation and structural characterization of natural products.

Chemical ecology, communication and microbial competitions.

Valorisation of microbial molecules: antimicrobials, biopesticides, food preservation, bioremediation, biomaterials.

Pre-requisites:

This course is intended for students with a M1 degree in biochemistry, molecular biology, cell biology, genetics, chemistry or biological chemistry, doctors, pharmacists and veterinarians, and engineers from leading schools specialising in the fields of life sciences and chemistry.

Evaluation:

Date of the evaluation: M2S3

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

The teaching unit is organized around lectures, conferences and tutorials on the various topics. A written exam and an oral presentation on an article in pairs will sanction the validation of the acquired knowledge.

Contact(s):

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& Soizic Prado: soizic.prado@mnhn.fr

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (*Environment Health*)

SPECIALIZATION: M2-MES, *Microbiology, Environment, Health*

Title of the module: ES22 - Environmental Genomics and Biotechnological Applications (ES22/MU5BM655/GENOTECH)

Start date: October **End date:** October

Coordinator(s): Raphaël LAMI, Maître de Conférences SU, Observatoire de Banyuls/Mer

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	6	20	10	30	2	30	20

Objectives of the module:

Recent and high throughput approaches to the analysis of the specific and functional diversity of environmental microorganisms are at the heart of many fundamental and applied research issues. In this teaching unit, we propose to review these tools, their application methods, and their interests to understand the place of microorganisms in their environment: high throughput sequencing, metagenomics, bioinformatics and phylogenetics approaches for the analysis of these important data sets. In a second step, we propose to examine the prospects for biotechnological applications of these tools in industrial laboratories.

Key words:

Microbial biodiversity; Environmental genomics; Valorisation of microorganisms; "Project" teaching unit.

Target skills:

Knowledge of molecular approaches to environmental microbiology and their biotechnological applications.

Pre-requisites:

No prerequisites are mandatory but participation in the various courses in environmental microbiology and applied microbiology at Master 1 level is strongly recommended.

Evaluation:

Date of the evaluation:

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

Written and oral exams, covering the proposed courses/TD/TP and by project.

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES23 - Aquatic Quality and Microbiological Risks (ES23/MU5BM645 /AQUAMICRO)

Start date: October End date: October

Coordinator(s): Fabien Joux (MC, SU) & Julia Baudart (MC, SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	6	22	10	30+5 personal work	2	30	18 including 9 SU

Objectives of the module:

Aquatic environments are under increasing pressure from pollution (microbiological and chemical) generated by human activities. These pollutions have serious consequences on ecological quality of the system (eutrophication), tourist economy (insalubrity, nuisances), aquaculture production (mortality, prohibition of sales) and human health (presence of opportunistic and pathogenic microorganisms or toxic algal blooms). This teaching unit addresses the themes of ecological dysfunction, bio-depollution, microbial ecotoxicology and the control of microbiological health in aquatic environments. The lessons will largely take the form of practical workshops devoted in particular to techniques for studying the degradation of pollutants, the detection of microorganisms of health interest by innovative methods and various ecotoxicological tests using microorganisms.

Key words:

Eutrophication, bio-depollution and microbial ecotoxicology.
Pathogenic, opportunistic or toxic microorganisms, aquatic environments.

Target skills:

- Knowledge of the different microorganisms responsible for health risk in aquatic environments (viruses, bacteria, cyanobacteria, microalgae): ecology, detection, regulations, health consequences, control.
- Analyze the impacts of pollutants on aquatic microorganisms: ecotoxicological laboratory tests, field studies, calculation of toxicity parameters.
- Eutrophication processes, degradation of organic matter in aquatic environments, wastewater treatment.
- Biodegradation of organic micropollutants and bioremediation of heavy metal pollution.

Pre-requisites:

Good knowledge of general microbiology, basic knowledge of microbial ecology and sanitary microbiology is required.

Evaluation:

Date of the evaluation: December/January.
Evaluation procedure and scoring: x Written, x Practical, Continuous Assessment, Oral
Written exam (60 points) and TP report (40 points).

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES25 - Technology Transfer & Living Technologies (ES25/MU5BM073/VALO)

Start date: November-December End date: November-December

Coordinator(s): H el ene Salin (MNHN) & Julien FELLAH (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	3	24	0	6	1	30	20

Objectives of the module:

The objectives are:

- make students aware of the importance of transferring research results to the citizens;
- present to them the different possibilities of valorisation and the means available to implement such projects (intellectual property, patent registration, technology transfer, start-up creation, etc.);
- to introduce them to the world of business related to living technologies and the associated professional opportunities.

Key words:

Technology transfer of research results, intellectual property, living technologies, company creation.

Target skills:

- Ability to replace the challenges of research commercialization in the current socio-economic context at the national and international levels,
- Ability to address intellectual property issues, including with SATT Lutech stakeholders,
- Understanding the means offered to researchers from public institutions and private sector to innovate, develop, transfer their technologies, inventions and create their own business, with the participation of public institution development managers and business managers from the Agoranov incubator,
- Become aware of regulatory and market aspects in any valorisation project,
- Discover examples of valorisation, the personal careers of business creators as well as the business world related to living technologies.

Pre-requisites:

No prerequisites are required to follow this course.

Evaluation:

Date of the evaluation: 29/11/2019

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

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES26 - *In vivo* gene transfer (ES26/MU5BM083/TRANSGEN)

Start date: November-December End date: November-December

Coordinator(s): Laurent Coen (MNHN) & Marie-Stéphanie Clerget-Froidevaux (MNHN)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	3	3	3	24	1	30	18

Objectives of the module:

The objective is to allow students to carry out/interpret somatic gene transfer experiments in an integrated (organism context) and evolutionary (xenope/mouse comparison) context.

Key words:

Somatic gene transfer in vivo, transcriptional regulations, nuclear receptors, RNA interference, thyroid hormones, integrated system.

Target skills:

This study examines thyroid hormone-induced regulation in parallel in two animal models, the mouse (mammalian) and xenope (amphibian). We will analyze, on the one hand, the involvement of thyroid hormones during metamorphosis in tadpoles and, on the other hand, their involvement in the implementation of regulations in the newborn mouse. These two models will allow to address the notions of positive and negative regulation of hormone transcription. The function of thyroid hormones and their receptors will be studied using quantifiable reporter genes (luciferase), placed downstream of regulatory regions "responding" to thyroid hormones.

Pre-requisites:

No prerequisites are required to follow this course.

Evaluation:

Date of the evaluation: Evaluation at the end of the week (Friday afternoon)

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

Participation (oral note, 40 points), and written exam (60 points): analysis of results similar to those obtained during the week.

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (*Environment Health*)

SPECIALIZATION: M2-MES, *Microbiology, Environment, Health*

Title of the module: ES27 - Video microscopy, confocal microscopy and digital imaging (ES27/MU5BM084/IMAGIN)

Start date: November-December

End date: November-December

Coordinator(s): Marc Gèze (MNHN)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	3	8	6	16	1	30	8

Objectives of the module:

The content of this teaching unit is essentially a practical approach to tools and methods for visualizing cellular structures and compartments by fluorescence microscopy.

A series of courses will provide an introduction to the basics of the field.

At the microscopy centre (CEMIM), different biological sample labelings (on cells in culture) will be performed, then the different preparations will be observed on two fluorescence microscopes (wide field with multi-dimensional and confocal acquisition). Students will participate to the acquisition of 2D and 3D images. In the computer room they will perform the processing (including deconvolution) and analysis of images with free software under Linux.

Key words:

Photonic microscopy; Confocal; Fluorescence; Deconvolution; Image processing and analysis ; Cellular imaging.

Target skills:

The objective of this workshop is to provide the basics of fluorescence microscopy and digital imaging concepts. It will be shown, based on examples, the entire image acquisition, processing and analysis chain.

Pre-requisites:

No prerequisites are required to follow this course.

Evaluation:

Date of the evaluation:

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

This teaching unit will be evaluated by a written exam (2 hours) and a written report to be given later.

Contact(s):

Marc Gèze: marc.geze@mnhn.fr

DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES28 - Integrative physiology of microorganisms (ES28/MU5BM691/PHYMICRO)

Start date: November-December

End date: November-December

Coordinator(s): Raphaël Lami (SU) & Fabien Joux (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	6	0	10	30	2	30	18

Objectives of the module:

After presenting the different interests in studying microbial models, we will present transformation techniques, gene inactivation, continuous gene expression monitoring, transcriptomics and comparative genome analysis approaches. These techniques will be illustrated by various biotechnological, ecophysiological or bioremediation studies. In the second part of this teaching unit, we will address the mechanisms of cellular communication and signalling pathways in microorganisms that are at the heart of many research issues in cellular biology and environmental sciences and have many biotechnological extensions.

Key words:

Microbial models, physiology, cell communication, signalling pathways.

Target skills:

Microbial genetics, ecophysiology, biotechnological applications, bioremediation.

Pre-requisites:

Knowledge of microbiology and genetics.

Evaluation:

Date of the evaluation:

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

Written exam (50 pts) / Oral exam (25 pts) / TP report (25 pts).

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (*Environment Health*)

SPECIALIZATION: M2-MES-MCT, *Microbiology, Environment, Health; Molecules and Therapeutic Targets*

Title of the module: ES30 – Microbial secondary metabolites: from genome mining to structural characterization (ES30/ MU5BM097/METASTRUC (ex-ISABIO))

Start date: December **End date:** December

Coordinator(s): Soizic Prado (MNHN) & Séverine Zirah (MNHN)

Objectives of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	3	3	18	9	1	30	18

Objectifs de l'UE :

Learn methods of natural product chemistry with approaches from gene to molecule: from genome mining to isolation and structural characterization by NMR and mass spectrometry.

Key words:

Microbial secondary (specialized) metabolites, genome mining, structural characterization, NMR, mass spectrometry.

Target skills:

Skills on microorganism genome mining methods for the discovery of biosynthetic gene clusters.
Skills on isolation and structural characterization of natural products by mass spectrometry and NMR.

Pre-requisites:

This course is intended for students with a M1 degree in biochemistry, molecular biology, cell biology, genetics, chemistry, physical or biological chemistry, doctors, pharmacists and veterinarians, and engineers from leading schools specialising in the fields of life sciences and chemistry.
Basic knowledge on NMR and mass spectrometry is recommended.

Evaluation:

Date of the evaluation:

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

At the end of the training, the participants will present orally in pairs the structural description of a secondary metabolite based on experimental data.

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES32 - Natural or induced microbiological risks (ES32/MU5BM668/RIMINAP)

Start date: November-December

End date: November-December

Coordinator(s): Vincent Maréchal (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	6	60	0	0	2	30	45

Objectives of the module:

Present some key facts concerning the exposure of populations to microbial risks (emerging diseases, vector-borne infectious diseases, antibiotic resistance, bioterrorism, etc.), analytical and protective methods (vaccine policies, laboratory confinement, epidemiology, etc.).

Key words:

Emerging diseases, vector-borne viruses, pathogenic bacteria, epidemiology, biosecurity.

Target skills:

Understand microbial risks in their multiple dimensions, especially societal ones, understand their dynamics and risk assessment approaches.

Pre-requisites:

General knowledge of pathogenic microorganisms (viruses, bacteria, parasites and fungi).

Evaluation:

Date of the evaluation:

Evaluation procedure and scoring: x Written, Practical, Continuous Assessment, Oral
Written exam on course question + conference summary.

Contact(s):

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SU Secretary: Carine JOSEPH (BMC) : sciences-master-bmc-pedago1@sorbonne-universite.fr

DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES34 - Research Implementation – Application to Industry and Research (SU) (ES34 / MU5BM067)

Start date: November-December

End date: November-December

Coordinator(s): Alain SÉZEUR (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	3	20	10	0	1	30	20

Objectives of the module:

The purpose of this teaching unit is to promote knowledge of the social and economic environment in order to promote the value of research, to learn about the reality of how health industries work, and how to create innovative businesses. At a time when the pharmaceutical and biomedical industry is concentrating, commercialization is becoming more professional, but innovators often have little knowledge of the procedures for protecting their innovations through patents and have difficulty finding an industrialist capable of developing their inventions. This teaching unit aims to professionalize research-enterprise partnerships.

Key words:

Socio-economic environment, biomedical regulation, research promotion, health industries.

Target skills:

Willingness to integrate your future professional approach by taking into account the economic and regulatory context imposed by applied biomedical research, willingness to collaborate effectively in a research / industry partnership or willingness to better understand the biomedical industrial world.

Pre-requisites:

Willingness to integrate his/her future professional approach by taking into account the economic and regulatory context imposed by biomedical research.

Evaluation:

Date of the evaluation:

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

Obligation to attend all teaching courses + summary of 1 conference whose theme is given at the end of the courses.

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES35 – Laboratory internship

Start date: January End date: June

Coordinator(s): Sébastien Duperron (MNHN), Raphaël Lami (SU), Cécile Bernard (MNHN) & Fabien Joux (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
4	30	0	0	0	22	0	18

Objectives of the module:

The 2nd semester of M2-MES will be devoted to a practical internship (research or professionalization) in line with the training followed, allowing the student to benefit from a better practical knowledge of the laboratory, and possibly to establish contacts for a future professional integration. The internship should demonstrate the thinking, technical and methodological skills of students who are confronted with a new scientific or technical issue.

Key words:

Practical internship.

Target skills:

Practical internship in a research or R&D laboratory of public scientific and technological institutions (e. g. CNRS, INRA, IRSTEA, Universities), public administrative institutions (e. g. ANSES, ONEMA) or companies (e. g. Véolia, EDF).

Pre-requisites:

Students already trained in microbiology with an interest in the environment, industry and health.

Evaluation:

Date of the evaluation:

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

3 ECTS: report and defence of a scientific project.

27 ECTS: final report and defense of the internship.

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MCT, Molecules and Therapeutic Targets

Title of the module: ES36 - Molecules and Therapeutic Targets (ES36/MU5BM104/MCT)

Start date: September End date: November

Coordinator(s): Séverine Zirah (MNHN) & Chahrazade El-Amri (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	12	78	30	12	11	29	25

Objectives of the module:

Apprehend the diversity (i) of molecules with therapeutic potential, from natural products to nucleic acids and (ii) of targets in different physiopathological contexts: proteins (enzymes, membrane receptors, nucleoproteic complexes, multiproteic complexes), nucleic acids (double strand DNA, RNA, telomeres).

Understand the general approach for validation of therapeutic targets in different physiopathological contexts: infectious diseases, neurodegenerative diseases, cancer...

Understand the different strategies for the discovery and characterization of therapeutic molecules.

Apprehend natural product diversity and strategies for discovery, isolation and structural characterization and pharmacological valorization.

The EU is organized around three axes: (1) natural product chemistry, (2) therapeutic targets and (3) nucleic acids.

Key words:

Structural biochemistry, natural products, gene therapy, pharmacology.

Target skills:

Apprehend a scientific question in a multidisciplinary perspective.

New paradigms in drug discovery.

Molecular tools, biophysics methods and omics.

Natural products: characterization and valorisation.

Transversal skills, scientific analysis and openness to the socio-economic world (applied research).

Pre-requisites:

This course is intended for students with a M1 degree in biochemistry, molecular biology, cell biology, genetics, chemistry or biological chemistry, doctors, pharmacists and veterinarians, and engineers from leading schools specialising in the fields of life sciences and chemistry.

Evaluation:

Date of the evaluation:

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

A written examination that covers all three axes (natural product chemistry, therapeutic targets, nucleic acids), based on extracts of recent scientific articles.

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MCT, Molecules and Therapeutic Targets

Title of the module: ES37 - Scientific analysis (ES37/MU5BM051)

Start date: October-November

End date: October-November

Coordinator(s): Séverine Zirah (MNHN) and Chahrazade El Amri (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	6	0	0	0	10	6	25

Objectives of the module:

Develop scientific analysis skills in the field of research and development. At the end of this teaching unit, students will have acquired an analytical ability to identify important points in the published scientific data and to explain them clearly. They will also have acquired the ability to summarize and criticize scientific documents.

Key words:

Scientific analysis.

Target skills:

Analysis of scientific documents, oral presentation skills.

Pre-requisites:

This course is intended for students with a M1 degree in biochemistry, molecular biology, cell biology, genetics, chemistry or biological chemistry, doctors, pharmacists and veterinarians, and engineers from leading schools specialising in the fields of life sciences and chemistry.

Evaluation:

Date of the evaluation:

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

Two oral presentations to the teaching team.

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MCT, Molecules and Therapeutic Targets

Title of the module: ES38 - Project in Molecular and Cellular Biology (ES38/MU5BM091)

Start date: January End date: January

Coordinator(s): Séverine Zirah (MNHN) & Chahrazade El-Amri (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	6	0	0	0	10	6	25

Objectives of the module:

Develop skills to elaborate and defend a scientific project. Prepare a document permitting to evaluate the project feasibility and defend the project with an oral presentation.

Key words:

Scientific project.

Target skills:

Make a bibliographical study on a subject that is proposed within the framework of the practical internship, to show the originality of the project and to specify the experimental approaches that will be implemented within the allocated time.

Pre-requisites:

No prerequisites are required to follow this course.

Evaluation:

Date of the evaluation:

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

A 20-page manuscript evaluated by two reporters and an oral presentation to the teaching team will sanction the teaching unit validation.

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MCT, Molecules and Therapeutic Targets

Title of the module: ES39 - Laboratory internship

Start date: January End date: June / September

Coordinator(s): Séverine Zirah (MNHN) & Chahrazade El-Amri (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
4	30	0	0	0	22	35	25

Objectives of the module:

Develop thinking, technical and methodological skills of students in a context of practical research work in an academic or private laboratory.

Key words:

Practical internship.

Target skills:

Practical internship in a research or R&D laboratory of public scientific and technological institutions (e. g. CNRS, INRA, INSERM, Universities), the pharmaceutical industry, or Biotecs.
Written and oral presentation skills.

Pre-requisites:

This course is intended for students with a M1 degree in biochemistry, molecular biology, cell biology, genetics, chemistry or biological chemistry, doctors, pharmacists and veterinarians, and engineers from leading schools specialising in the fields of life sciences and chemistry.

Evaluation:

Date of the evaluation:

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

A 30-page manuscript evaluated by two reporters and an oral presentation to the teaching team will sanction the internship unit validation.

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (*Environment Health*)

SPECIALIZATION: M2-MES, *Microbiology, Environment, Health*

Title of the module: ES42 - Diversity and ecodynamics of toxics (ES42/MU5BM619a/DIVTOX)

Start date: November-December **End date:** November-December

Coordinator(s): Katia COMTE (MNHN), Cécile Bernard (MNHN), Sébastien Duperron (MNHN), David SIAUSSAT (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	3	24		6		30	18

Objectives of the module:

The teaching unit presents the diversity of toxic substances that affect ecosystem health and human health. Toxics include natural toxins (produced by prokaryotic and eukaryotic organisms) and contaminants related to human activities. Beyond describing the diversity of these toxic substances, a lesson on their structural modifications and toxic effects will be addressed in an environmental context.

Key words:

- Diversity and mode of action of toxins and toxins
- Contaminants related to human activities
- Modification of contaminants in an environmental context

Target skills:

Pre-requisites:

No prerequisites are required to follow this course.

Evaluation:

Date of the evaluation: **November-December**

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

Validation of the teaching unit by a written examination including article analysis and/or questions on lessons.

Contact(s):

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Museum Secretary: Farida SELMET (MNHN) : farida.selmet@mnhn.fr;

SU Secretary: Carine JOSEPH (BMC) : sciences-master-bmc-pedago1@sorbonne-universite.fr

DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (Environment Health)

SPECIALIZATION: M2-MES, Microbiology, Environment, Health

Title of the module: ES43 - Ecotoxicology and Risk Assessment (ES43/MU5BM619b/TOXRISK)

Start date: November-December End date: November-December

Coordinator(s): Katia Comte (MNHN), Cécile Bernard (MNHN), Sébastien Duperron (MNHN), David Siauxsat (SU)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
3	3	24	6		1	30	18

Objectives of the module:

The teaching unit presents the effect of toxic substances (natural toxins and contaminants related to human activities) on living organisms, and the approach for assessing the associated risks. The scales covered range from the cell to ecosystem functioning. Examples of toxic risk analysis and monitoring will be detailed. On the basis of the effects of toxicants and in relation to risks, the development, use of toxicity tests and bioindicators will be presented.

Key words:

- Effects of toxic substances in organisms and ecosystems.
- Environmental quality and bioindicators.
- Risk analysis and decision.

Target skills:

Pre-requisites:

No prerequisites are required to follow this course.

Evaluation:

Date of the evaluation: November-December

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

Validation of the teaching unit by a synthesis exercise (prepared during the EU).

Contact(s):

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Museum Secretary: Farida SELMET (MNHN) : farida.selmet@mnhn.fr;

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (*Environment Health*)

SPECIALIZATION: M2-MES-MCT, *Microbiology, Environment, Health; Molecules and Therapeutic Targets*

Title of the module: ES44 - Initiation to genome editing with CRISPR/Cas9 (ES44/MU5BM071/CRISPR)

Start date: December-January **End date:** December-January

Responsible(s): Anne de Cian (MNHN) & Laureline Roger (MNHN)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
1	3	2	12	24	1	38	12

Objectives of the module:

Practical and theoretical course in order to understand the design, the validation and the analysis of a genome editing experiment with CRISPR/Cas9.

- Day 1: Overview of the CRISPR/Cas9 complex mechanisms of action and the related applications (theoretical course). Undertaking a cutting experiment *in vitro* with CRISPR/Cas9 and analysing the result (practical course).
- Days 2-3: Designing RNA guides in order to inactivate a gene of interest or in order to induce a targeted modification (bioinformatics). Cloning RNA guides in an expression vector and analysis of sequencing results (practical course).
- Days 4-5: Genotyping and analysing the results of a genome editing experiment (theoretical course + practical course based on examples).

Key words:

CRISPR/Cas9, Genome editing, gene inactivation, molecular biology.

Target skills:

Molecular biology (Cloning, PCR, Electrophoresis, enzymatic digestion)

Bioinformatics (find and visualise a gene in a database, identify the best RNA guides in a given region (CRISPOR.tefor.net), handle sequences *in silico* (cloning, PCR).

Pre-requisites:

Molecular and Cellular biology (Bachelor degree level). Bioinformatics (basics). Notions in CRISPR/Cas9 technology would be appreciated.

Evaluation:

Date of the evaluation: December-January

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

The marking will be based on an oral presentation of the results by the students (as a pair) (day 5) and on their participation during the week.

Contact(s):

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DEGREE TITLE: Biodiversity, Ecology, and Evolution

PROGRAM: ES (*Environment Health*)

SPECIALIZATION: M2-MES-MCT, *Microbiology, Environment, Health; Molecules and Therapeutic Targets*

Title of the module: ES50 - Introduction to Research: Laboratory internship

Start date: September **End date:** June

Coordinator(s): Philippe Grellier (MNHN)

Organization of the module:

Semester	ECTS	CM (h)	TD (h)	TP (h)	Number of Weeks	Hours per week	Maximum participants
34	15	0	0	0	12	0	5

Objectives of the module:

The objective of the workshop is to provide an introduction to the student's research through a direct immersion in one of the host teams of the ES Master Program. The purpose of this training is to confront the student with the reality of research around a project that will be proposed to him and that he will have to conduct under the direction of a supervisor, based on the biological model(s) or theme(s) developed by the host laboratory. This project may cover broad thematic areas ranging from fundamental microbiological biology projects, for example, to more applied projects such as the development of new therapeutic strategies.

Key words:

Training in laboratory research.

Target skills:

Conduct research in the laboratory; acquire good laboratory practices. Compliance with health and safety conditions. Conduct a bibliographic search.

Pre-requisites:

The student must have a level of M1/M2 or equivalent.

Evaluation:

Date of the evaluation: all year round

Evaluation procedure and scoring: x Written, Practical, Continuous Assessment, Oral
Scientific report (50% of the grade) and oral presentation (50% of the grade).

Contact(s):

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