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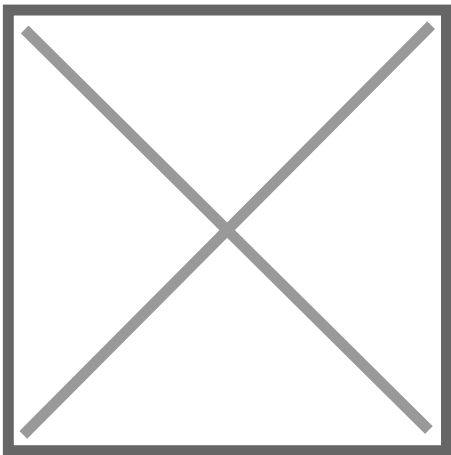
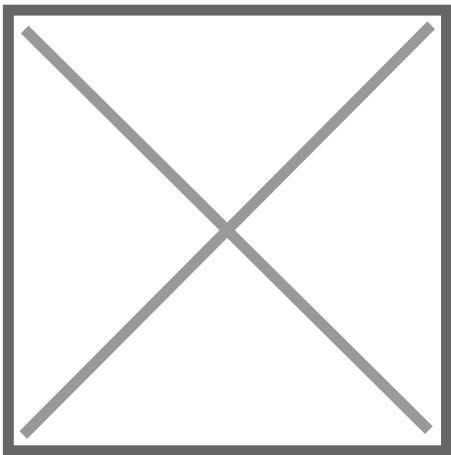
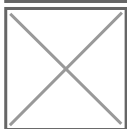
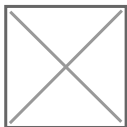
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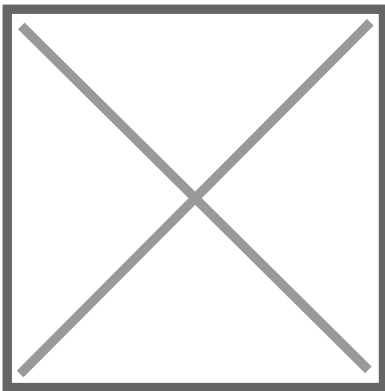
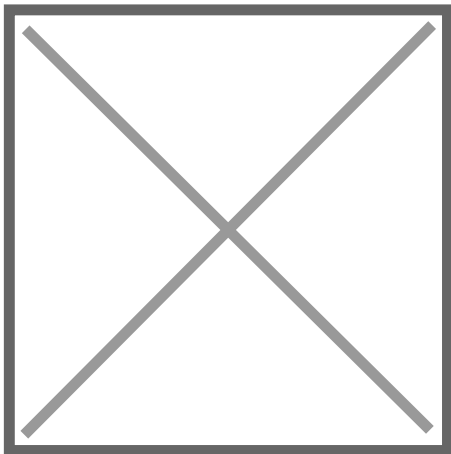
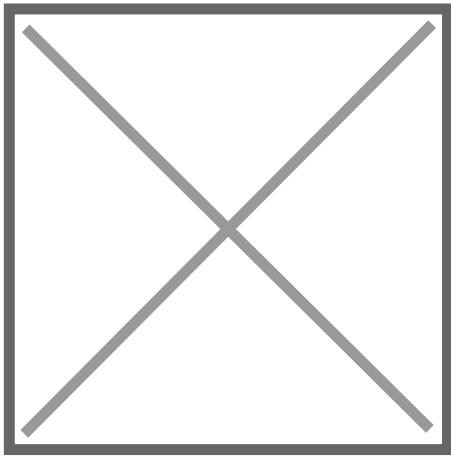
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Le mail de partage a bien été envoyé.

Add to Compare

M2 Systems and Synthetic Biology





Master's degree

Specialisations Biologie-AgroSciences | Biologie moléculaire et cellulaire

Enrolment type

Full-time academic programmes Life-long learning

Language(s) of instruction

English

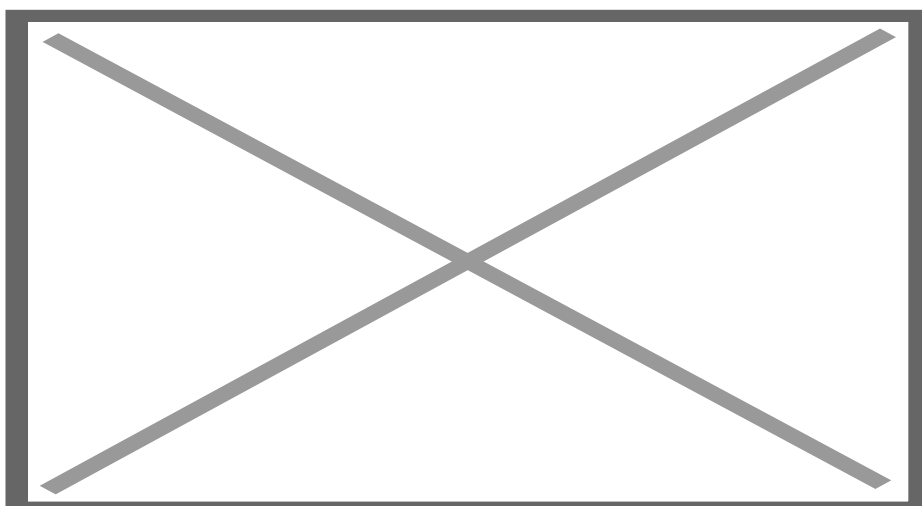
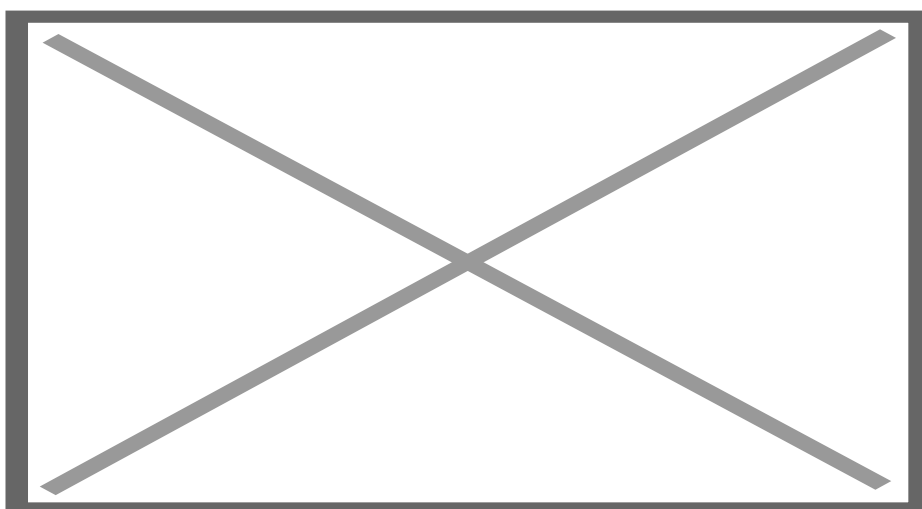
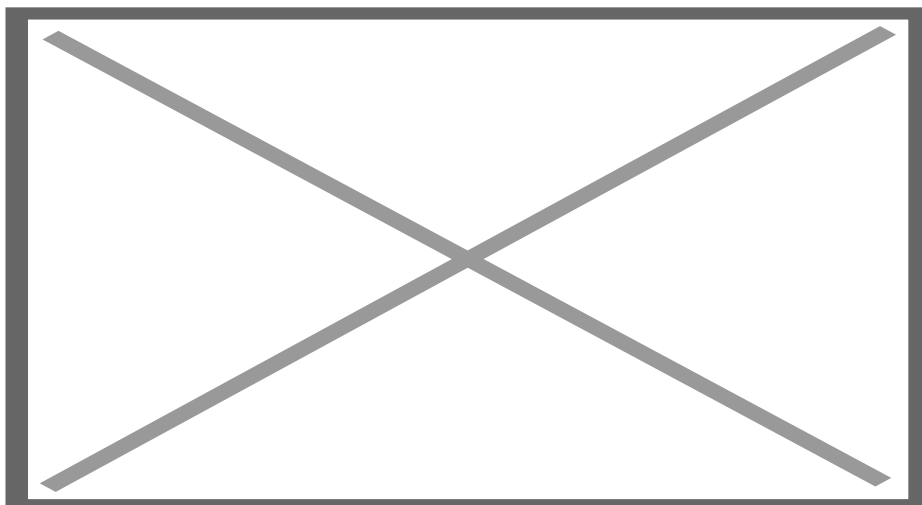
The vigorous development of Systems and Synthetic Biology constitutes a huge challenge that must be met both from the research and education perspectives. M2 SSB represents the first step towards nurturing a new brand of researchers and engineers to face up to the challenge.

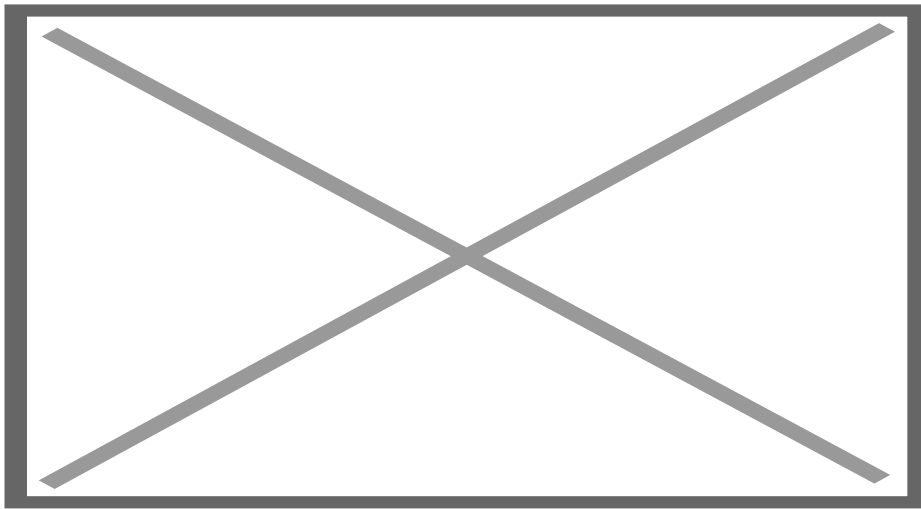
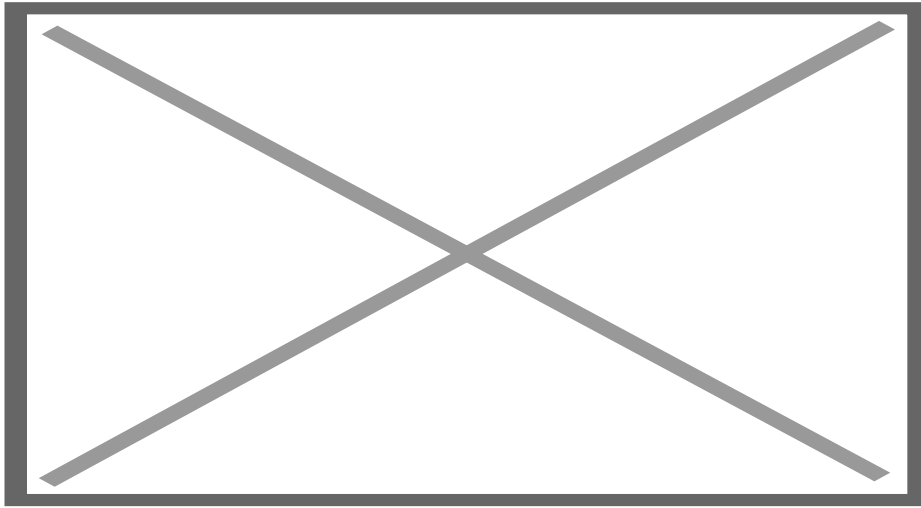
During the first semester, from September to end of January, students must attend 5 core compulsory modules and 5 elective modules (chosen among 12), for a total of 30 European Credits (ECTS). Refresher courses in either biology or mathematics and computer science are also proposed.

The second semester, from February to end of July, consists in a 6-months research training. Students may perform this internship in one of the academic laboratories or biotechnology companies located on site or elsewhere in France or abroad.

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Information

- [Overview](#)
- [Application requirements](#)
- [Schedule](#)

Présentation

Skills

- Apply engineering approaches to biology.
- Design, model and predict the behavior of biological synthetic parts, circuits and chassis.
- Recommend and execute experimental plans to engineer and test synthetic biological systems.
- Integrate concepts and technologies across disciplinary boundaries.
- Conceive and develop collaborative research work within interdisciplinary teams with applications in Systems & Synthetic Biology (iGEM).
- Anticipate the economical and societal challenges of synthetic biology to plan future career paths.

Objectives

The aim of M2 SSB is to provide students from the Life Sciences, Mathematics, Engineering, Chemistry, Physical and Computer Sciences a mean to fruitfully engage in collaborative work across disciplinary boundaries, with applications in Systems & Synthetic Biology. Students undertaking the course will gain hands-on experience in experimental biology, modeling and designing. They will also enhance transversal capacities including planning a project, giving a seminar, perceiving the industrial, economical and ethical issues associated with these developing fields.

Débouchés

Career prospects

After a Master's or Master's + PhD: engineer (R&D, control, production, etc.)

After a Master's or Master's + PhD: researcher or lecturer

After a Master's or Master's + PhD: engineer (research and development, control, production, etc.) in the fields of health, pharmaceuticals, agri-food, biotechnologies, instruments and reagents, cosmetics, pollution control and the environment.

Sectors of activity: fundamental or applied research in Biology, Health or Ecology in academia or the private sector

After a Master's + PhD: researcher or lecturer

After a Master's or Master's + PhD: engineer (Research & Development, control, production, etc.)

Design/research engineer in an R&D department in the ophthalmic industry

After a Master's degree: Data scientist

After a Master's degree: Research analyst

Ingenieur R&D

R&D Project Manager

R and D Project Manager

Chef de projet

Design engineer in the industrial sector
Design engineer in the research / scientific sector
Design engineer industry / public research
Academic staff
Design Engineer
Research & Development Engineer
Research and Innovation Manager
Project Manager
Production Engineer
Project manager in biotechnologies, biotherapies or healthcare innovation
Ingénieur.e recherche et développement
Private-sector companies, including agricultural production
Manufacturing Process (CAM) Technician
Production Technician
Product Development Technician
Laboratory Manager
Research or Design Engineer
Research professions
enseignant.e-chercheur.se (après un doctorat)
Design Engineer
Research Engineer
Design Engineer
Research Engineer
Development Engineer

Further Study Opportunities

Biology-Agrosciences
R&D researcher or data modelling and analysis expert in leading-edge companies or laboratories.
Data Scientist, Data Analyst, Ingénieur·e en Machine Learning dans des secteurs innovants (tech, finance, santé, énergie, etc.) ;
PhD
Doctorat en Bioinformatique

PhD in Chemistry / Biology

Interdisciplinary PhD in Sustainability Science (many disciplines possible)

Engineering, research and development

Students with a 2nd year Master's degree have the possibility to pursue doctoral research.

PhD thesis

Admission

Admission Route

Life Sciences

Capacity

Available Places

15

Target Audience and Entry Requirements

Applicants may come from Universities or from Engineering schools. After a first year of master (M1), or an equivalent qualification (4 years of successful higher education after finishing high-school), in either Biology, applied Mathematics, Computer Science, Chemistry or Physics. Bi-disciplinary curriculums including biology is favored, but highly-achieving and motivated students in any of the cited disciplines can apply.

Période(s) de candidature

Inception Platform

From 21/01/2026 to 04/07/2026

Supporting documents

Compulsory supporting documents

Motivation letter.

All transcripts of the years / semesters validated since the high school diploma at the date of application.

Curriculum Vitae.

Additional supporting documents

Letter of recommendation or internship evaluation.

or the names and addresses of 2 referees

Document at your convenience.

any other document that you consider important for the evaluation of your application

Every documents and achievements which could support the candidacy (report, case study, partnership prospectus, event creation, etc.).

VAP file (obligatory for all persons requesting a valuation of the assets to enter the diploma).

Recommendation letters.

Supporting documents :

- Residence permit stating the country of residence of the first country
- Or receipt of request stating the country of first asylum
- Or document from the UNHCR granting refugee status
- Or receipt of refugee status request delivered in France
- Or residence permit stating the refugee status delivered in France
- Or document stating subsidiary protection in France or abroad
- Or document stating temporary protection in France or abroad.

Programme

Refresher and Supplementary Courses

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	practical class	directed study/practical class
Introduction to Biology	0	Semestre 1	16	16	8			

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	practical class	directed study/practical class
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Introduction to Biology

ECTS : 0

Semester: Semestre 1

Detail

Lecture: 16

Practical study : 8

Directed study: 16

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

none

Programme/contents

This 4course covers the following topics:

- Molecular Biology
- Genomics
- Systems Biology
- Synthetic Biology
- Structural Biology
- Evolution
- Cell Biology
- Bioinformatics
- Developmental Biology
- Presentation of the laboratory and of the Good Laboratory Practice

Laboratory Practice

- Discover the key Molecular Biology and Biochemistry tools and techniques used daily in biology laboratories.

Learning objectives

To facilitate research at common borders, the advanced introduction course aims at fostering a better understanding of the expectations, constraints, approaches and mode of thinking of a scientific partner across disciplines.

Within two week, this course brings participants belonging to a non-biological community (mathematics, engineering, chemistry, physical or computer sciences) to understand the research frontiers in biological sciences.

To reach this goal, key objects and concepts explaining the current research questions and methods will be presented and all the important and recent subdisciplines of biology will be covered.

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Introduction to Mathematics and Computer Science for Biology	3	Semestre 1	15	7.5				



Introduction to Mathematics and Computer Science for Biology

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 15

Directed study: 7.5

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

The prerequisites for the course are a basic knowledge of discrete mathematics and an eagerness to engage in computational analysis. Students are assumed to have a solid background in biology.

Programme/contents

Syllabus:

- Probability-Statistics: Descriptive statistics, Probability, Random variables, Distributions, Central Limit Theorem, Hypothesis testing, Linear regression, Probabilistic modeling, Tests
- Data Analysis & Simulation: Introduction to R language, Introduction to Linux

Learning objectives

The course will present basic computational and mathematical concepts needed for genomic and data analysis.

At the end of the course, the student should be able to:

- perform basic statistical analysis on datasets
- understand formal concepts used for describing biological problems
- use R for basic data analysis
- be autonomous in a Unix/Linux environment

Overall organisation

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Advanced introduction to Mathematics and Computer Science for Biology	0	Semestre 1	7.5	10				

Advanced introduction to Mathematics and Computer Science for Biology

ECTS : 0

Semester: Semestre 1

Detail

Lecture: 7.5

Directed study: 10

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

The prerequisites for the course are a basic knowledge of discrete mathematics and an eagerness to engage in computational analysis. Students are assumed to have a solid background in biology.

Programme/contents

Syllabus:

- Data Analysis & Simulation
- Machine Learning: Supervised learning, Unsupervised learning, Evolutionary algorithms
- Modeling (regular languages): Regular expressions, Finite automata, Formal grammar
- Introduction to discrete modelling and the use of formal mathematical structures to represent problems.
- Data Analysis & Simulation: Introduction to Python

Learning objectives

The course will present basic computational and mathematical concepts needed for systems biology approaches and data analysis and simulation. The course should enable students to understand more sophisticated mathematical and computational notions encountered in other modules.

At the end of the course, the student should be able to:

- understand formal concepts used for describing biological problems
- describe basic notions of machine learning
- understand formal concepts used for describing biological problems
- use Python for basic data analysis

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
<u>Innovation and entrepreneurship in biotechnology (IEB)</u>	3	Semestre 1	22.5					

Innovation and entrepreneurship in biotechnology (IEB)

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 22.5

Tutored project 0

Language(s) of instruction

Anglais

Remote teaching

non

Programme/contents

1/Interactive session about entrepreneurship

Thoughts and discussions about entrepreneurship and its scope, leading to the identification of modules needed for business start-up

2/ Presentation of support organizations

Global presentation and Focus on Genopole: its ecosystem, Biotechnology entrepreneurship specificity and the early-stage support program Shaker.

3/ Testimonials of actors

Entrepreneurs / Incubator / Funders - Presentation and meeting with the Paris Saclay Cancer Cluster stakeholders, followed by an on-site visit.

4/ Student's case study : Preparation of a pitch for a biotech start-up project

session of projects presentations and guidelines of this pitch exercise

personal and team students work

restitution with an oral presentation

Learning objectives

Give an overview of steps and procedures for entrepreneurship, with a focus on biotechnologies

Overall organisation

20 hours of face-to-face teaching spread over 2

Core Modules

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di
Biological Parts and Devices	3.5	Semestre 1	11	9					

Biological Parts and Devices

ECTS : 3.5

Semester: Semestre 1

Detail

Lecture: 11

Directed study: 9

Language(s) of instruction

Anglais

Remote teaching

non

Learning objectives

This module will equip the student with broad knowledge of synthetic biology, and the engineering of biological parts and devices. Students will identify and define key concepts in Synthetic Biology / Engineering Biology: history, philosophy, objectives, positioning between biology and engineering, standardisation, chasses, and International Genetically Engineered Machine (iGEM).

They will be able to describe the roles of different genetic parts: promoters, ribosome binding sites, terminators, genes, reporters, plasmids, small RNAs, and ribo-regulators. They will be able to retrieve those parts from the common parts registries, and identify and annotate them in a given DNA sequence.

The students will be able to interpret genetic designs for expression of single and multi-gene circuits with different types of behaviour: constitutive, inducible, dynamic oscillatory, spatially patterned. They will be able to construct simple circuits using RNA, protein, and nucleoprotein parts; while taking into account expression levels (transcription and translation), codon usage, RNA stability, protein half-life, noise, and burden of the circuits.

The students will survey and compare prokaryotic and eukaryotic genetic circuits from literature, identifying differences between them. They will be able to troubleshoot malfunctioning biological circuits and build computational models of simple circuits.

Finally, they will be able to critique biological circuit designs, propose improvements to the designs, and justify and defend those improvements.

Overall organisation

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di le c
Genome Engineering	3.5	Semestre 1	11		9				

Genome Engineering

ECTS : 3.5

Semester: Semestre 1

Detail

Lecture: 11

Practical study : 9

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

none

Programme/contents

This course will cover up-to-date techniques for DNA assembly (eg Gibson, Golden Gate, LIC, SLIC...), for site-directed DNA recombination (eg Cre-Lox, integrase, etc.), multiplex gene and genome editing (eg PACE, CRISPR, TALEN...), genome-scale engineering (eg genome reduction, genome synthesis, genome transplantation, MAGE, CAGE...) and explore the implications of continued advances toward the development of ? exibly programmable “chassis”, novel biochemistries (eg non-canonical amino acids, XNA...), and safer engineering (eg genetic confinement, synthetic consortia...).

Learning objectives

Genome engineering technologies are revolutionising Life Sciences as they enable the rational design of synthetic biological systems. Recent advances in genome engineering have dramatically expanded our ability to engineer cells in a directed and combinatorial manner.

At the end of the course, students will be able to:

- Explain the principles of several genome engineering techniques
- Adapt genome engineering techniques to a given scientific issue
- Conceive orthogonal systems and explain their advantages and limitations
- Evaluate on-going research in the development

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di le c
Metabolic Engineering	3.5	Semestre 1	12	8					

Metabolic Engineering

ECTS : 3.5

Semester: Semestre 1

Detail

Lecture: 12

Directed study: 8

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Understanding metabolic pathways and enzymatic reactions is crucial. A background in molecular biology, gene expression, regulation, and recombinant DNA technology is typically required, as well as knowledge of chemical or biochemical engineering principles. **A solid understanding of central metabolism and major metabolic pathways is also essential.** In addition, the use of computational bioinformatic tools is required in this course.

Programme/contents

The purpose of the metabolic engineering is to generate a cell factory that produces cost-effective molecules at industrial scale. This course aims to provide the basic concepts and tools that have been developed the past 20 years when designing, building and testing metabolic pathways for bioproduction purposes. Practical applications and successes will be surveyed by an industrial (Abolis Biotech). A particular emphasis will be given to two research forefronts of metabolic engineering (1) how can we learn to improve pathway performances using flux analysis and genetic engineering and (2) how pathway engineering can be used to build biosensor and biocomputation devices.

Learning objectives

Metabolic engineering is becoming a mature field of research with many industrial applications. It is a process of optimizing native metabolic pathways and regulatory networks or assembling heterologous metabolic pathways for production of targeted molecules using molecular, genetic and combinatorial approaches.

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di le c
Synthetic Biology Practical Course	5	Semestre 1			45				

Synthetic Biology Practical Course

ECTS : 5

Semester: Semestre 1

Detail

Practical study : 45

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

none

Programme/contents

This course will cover all steps of a synthetic biology project (production of metabolites by a host), either for fundamental purposes such as understanding the rules controlling biological systems or for engineering purposes such as production of molecules of interest by living systems.

Emphasis will be put on the concept of process, with quality control checkpoints, discussions on the inherent and manageable variability of the input sources (the biological system – the human experimenter) and collective data analysis sessions.

As a practical course, it will recall general safety rules and good practices in the laboratory.

Learning objectives

The objectives of this course are:

- To practise classical molecular biology techniques at the bench for the purpose of synthetic biology, especially when students are not familiar with the wet-lab.
- To get the know-how of experimental acquisition of data from complex biological systems.
- To go through the process of a synthetic biology project, from its experimental design to data interpretation.

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di
Biosafety and Epistemology Questions on Synthetic Biology	2	Semestre 1	10						c

Biosafety and Epistemology

Questions on Synthetic Biology

ECTS : 2

Semester: Semestre 1

Detail

Lecture: 10

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

none

Programme/contents

The course will be divided into four parts:

I. Definitions and actors involved: synthetic biology "seen from the outside".

II. The majority position: from ethics to engineering of living matter

III. The critical capacities of researchers: limits or impotence of ethics?

IV. The unthinking of ethical posture: about the blind spots of biotechnological progress

V. Chemical toolkit as genetic firewall and reengineering living organisms.

Learning objectives

At the end of this course, students will be able to:

- describe the diversity of definitions, institutions and actors in synthetic biology in France.

- identify the dominant trend in the ethics of engineering of life.

- distinguish the plurality of points of view that the actors of synthetic biology have on their practice.

- analyse the unanswered questions that synthetic biology raises about biotechnologies

- conceive a reflexive approach towards synthetic biology by taking into account their own

Elective Modules

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Cell Factory Design	2.5	Semestre 1	11	3	6			



Cell Factory Design

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 11

Practical study : 6

Directed study: 3

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Several optional modules from Master 1 BMP and BA are highly recommended:

Systems Biology I

Systems Biology II

Cellular Economics

Programme/contents

In this course, we will seek to practically explore the “pipeline” of chassis design. The methods for the analysis of flux distribution, from constraint-based modelling (Flux Balance Analysis, Resource Balance Analysis, etc.) to dynamical modelling (Ordinary Differential Equations, etc.) are at the core of this course.

Learning objectives

Metabolic engineering and cell factory design are disciplines that sprung up at the interface of chemical engineering, biotechnology, biochemistry, classical genetics and modelling. In particular, the design of a cell factory involves global analysis of the production organism (genomics, transcriptomics, proteomics, metabolomics) coupled to the development of a dedicated, mathematical model of the whole cell in order to define in silico the optimization strategy and the required modification of the strain to be implemented through the means of genetic manipulations.

At the end of the course, students will be able to:

- Explore models enabling to handle in details entire cellular networks
- Evaluate different strategies for in silico cell factory design

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Chips for Molecular Evolution	2.5	Semestre 1			20			



Chips for Molecular Evolution

ECTS : 2.5

Semester: Semestre 1

Detail

Practical study : 20

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

none

Programme/contents

- Collective debriefing on the purpose of the practical course and the protocol

- Manipulations: preparing E. coli, pouring, degassing, baking, then peeling off the PDMS chip from the master mold, creating inlet/outlet, sealing the chip to a coverslip by using plasma treatment, injecting/spinning cells into chip's growth channels, preparing tubing and growth medium, flowing the growth medium into the device by using a syringe pump, performing image and data analysis on images previously generated using this type of chip

Learning objectives

The main pedagogical intention behind this training is to:

- introduce students to the use of the microfluidic tool for biology research, to highlight its specificities and potentialities.

- allow students to build/use on their own a specific microfluidic chip which allows monitoring growth, gene expression or mutation accumulation in single cells of rod-shaped bacteria on long timescales (i.e. few hundreds of generations)

At the end of the training, students will be able to:

- state the differences (advantages and disadvantages) between macrofluidic and microfluidic systems for biology research

- define and explain the main steps in the construction of a microfluidic chip

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Computational DNA Nanotechnology	2.5	Semestre 1	18					

Computational DNA Nanotechnology

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 18

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

1. **basics of computer science (complexity, automata theory, langage theory)**
2. **basics of the biology of DNA**

Programme/contents

1. **Presentation of DNA self-assembly, theory and experiments.**
2. **Biomedical applications of DNA self-assembly : reading and discussion.**
3. **Supervised project on the design of a DNA origami.**

Learning objectives

1. **Understand the basic principles of DNA self-assembly and DNA computing.**
2. **Understand basic applications of DNA nanotechnology in biology and medicine.**
3. **Learn how to design basic DNA nanostructures.**

Overall organisation

This class starts by a brief presentation of the computational aspects of DNA self-assembly and the experimental technique of DNA origami. This presentation is followed by a reading session in which the students are encouraged to present their favorite aspects in detail to their peers. The class ends with a practical assignment in the DNA origami design software <https://www.ens-lyon.fr/ensnano/>, in which the students are encouraged to design a shape having a high probability of folding in a test tube.

Bibliography

1. Fan Hong, Fei Zhang, Yan Liu, Hao Yan: DNA

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Computational Protein Design	2.5	Semestre 1	12	8				



Computational Protein Design

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 12

Directed study: 8

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

The course prerequisites are a basic knowledge of molecular and structural biology, bioinformatics and thermodynamics.

Learning objectives

This course provides an overview of the techniques used in computational protein design, from molecular modelling to in silico combinatorial library design, including those practical aspects associated with the integration of such computational techniques into a protein engineering project.

The course covers various aspects of the field, including an overview of protein molecular modelling and dynamics, protein activity modelling, protein engineering, and protein design techniques:

- Molecular modelling: atomistic, descriptor-based, and knowledge-based models; solvent representations, AI for protein structure prediction.
- Force field-based techniques: energy minimization and molecular dynamics.
- Docking techniques: protein-protein, protein-peptide, and protein-small molecule interactions.
- Descriptor-based modelling of biological activities: quantitative structure-activity relationship models.
- Knowledge-based modelling: rotamer libraries, large-scale analysis of propensities.
- Machine-learning and deep learning modeling.
- Protein design: search algorithms, combinatorial optimization, and library design.

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Machine Learning in Synthetic Biology and Metabolic Engineering	2.5	Semestre 1	20					

Machine Learning in Synthetic Biology and Metabolic Engineering

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 20

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Basic knowledge of Python programming and the use of Python libraries.

Learning objectives

At the end of this course, the student will be able to:

- Understand traditional learning methods such as multiple linear regression, support vector machines, random forests, and neural networks (dense, convolutional and recurrent) as well as active and reinforcement learning methods.
- Understand cross-validation methods for classification and regression
- Define the needs for experimental design and learning for classical problems in the construction of metabolic pathways and synthetic circuits developed in synthetic biology
- Design a synthetic circuit to be implanted in a biological system (cellular or acellular) capable of performing a basic learning operation (weighted sum, activation function)
- Use Python libraries (such as pyDoE, Keras, Scikit-Learn) to create an experimental design and simple learning on a biological data set.
- To be familiar with the use of learning methods in the fields of human health and image recognition.

Overall organisation

Teaching in this EU will include lectures in experimental design, machine learning, and their applications in synthetic biology and human health

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Environmental Biotech and Upstream Processing	2.5	Semestre 1	20					

Environmental Biotech and Upstream Processing

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 20

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Students attending the course should have a regular background in fundamental and applied microbial molecular biology: regulation of gene expression, nucleic acid methods, basics in (bio)chemistry and microbial physiology (Bachelor of Sciences or equivalent). Being a transdisciplinary course, diverse backgrounds are welcomed, as long as willingness to investigate missing or new concepts is a goal of the attendee.

Learning objectives

The development of a sustainable, bio-based economy that does not depend on fossil fuels for energy and commodities and has a low environmental impact is a major goal as well as a big societal challenge. Modern technologies have provided new ways for increasing knowledge, understanding bioprocesses and testing potential applications. This course will focus on topics like biodegradation and bioremediation of legacy as well as emerging pollutants (incl. heavy metals, pesticides and plastics) and microbial engineering for the use of renewable resources and their underlying biological and technological principles. It aims to give students clues to :

- understand the input of microbial genome sequences and integrated -omics strategies to fill in knowledge gaps concerning degradation pathways
- describe technological and analytical tools available in the field and envision the upstream processing (inputs, bottlenecks, gaps)
- analyse scientific literature, interpret data
- cross-analyze various scientific and

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Downstream Processing for Industrial Biotechnologie	2.5	Semestre 1	9	6				

Downstream Processing for Industrial Biotechnologie

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 9

Directed study: 6

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Basics in chemistry and physics (level L1 – Bac +1)

Fundamentals of Chemical Engineering : mass balance, material and heat transfer

Programme/contents

“Downstream Processing” applied to industrial biotechnology is defined as "all unitary operations aimed at extracting and purifying biomolecules resulting from the fractionation or bioconversion of renewable materials".

It is an essential step in biotechnologies and biorefineries, which aim to substitute fossil resources and develop new, more sober and ecological production processes from vegetal biomass. Indeed, it is generally the most expensive and the most impacting on the environment because of the number of operations required to obtain the final product(s).

The general objective of this course is to train executives capable of defining innovative, competitive and more environmentally friendly separation strategies by cleverly choosing and combining modern or more conventional technologies.

After the presentation of a rather broad panorama of the usual techniques, a reasoned choice guide will be proposed as well as courses to learn how to optimize and pre-dimension certain processes that are essential in biorefineries such as membrane filtration, electrodialysis, ion exchange, adsorption, gas-liquid absorption, liquid-liquid extraction, distillation or preparative chromatography.

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Nanobiology	2.5	Semestre 1	12		8			

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
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Nanobiology

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 12

Practical study : 8

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

none

Programme/contents

Syllabus:

INTRODUCTION

- Motivation and challenges for biology, health, nanotechnology, molecular storage
- Principle of electrical detection
- Experimental Setup
- Analysis of data

NANOPORES, NANOTUBES

- Protein channels
- Solid-states pores
- Biomimetic channels
- Hybrid pores
- Nanotubes and Nanochannels

DYNAMICS OF IONS TO BIOMOLECULES

- Introduction physical concept: polymer conformation, size, flexibility and rigidity, dilute and semi_dilute solution
- Ions
- Polymers
- biomolecules

APPLICATIONS

- Protein folding
- Ultrafast DNA and protein sequencing
- Mass and size discrimination by nanopores
- Biomarker and virus detection

PRACTICAL COURSE

- Lipid bilayer formation
- Protein nanopore insertion into membrane
- Electrical measurements

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Network Systems: Modeling and Analysis	2.5	Semestre 1	20					

Network Systems: Modeling and Analysis

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 20

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Mathematical background, basic knowledge on programming language and algorithmics, molecular and cellular biology

Learning objectives

Network analysis is widely used in system biology and precision medicine to gain a comprehensive understanding of molecular interactions. A network is a dynamical system represented structurally by a graph. The objective of this course is to provide the fundamental background in network analysis combining theoretical, computational and biological knowledge.

Topological analysis:

- Mastering the fundamental graph measurements with their algorithms,
- Compute the different centralities and apply them in biological study,
- Identify the class of a real/random networks to deduce their properties,
- Apply a topological analysis on a biological case to discover relevant properties.

Dynamical analysis:

The student should master and practically use:

- the basis Boolean network modelling,
- the basis of Petri nets modelling,
- the basis of neural network modelling,
- the design of a network model based on data and

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Rational Protein Engineering	2.5	Semestre 1			20			



Rational Protein Engineering

ECTS : 2.5

Semester: Semestre 1

Detail

Practical study : 20

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

none

Learning objectives

The objectives of this course are to provide students with an understanding of practical aspects developed in the laboratory for the study of proteins and, through concrete examples of recombinant proteins, illustrate the experimental methods for protein design and gene modification by mutagenesis in order to obtain the desired function by controlling the structure / function relationships.

At the end of the course, students will be able to:

- Perform wet lab experiments for the study of proteins
- Remodel genes by site-directed and / or random mutagenesis
- Compare in vivo and in vitro studies of the activity of the wild type protein and its mutants

Correlation of experimental results with the theoretical model developed using the skills acquired in the module “Computational protein design” is strongly encouraged.

Overall organisation

This module will be organised in 3 sessions scheduled over 3 days on the basis of experimental constraints.

Type of assessment

Evaluation Continue non Intégrale

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Experimental Design and Statistical Analysis for Next Generation Sequencing	2.5	Semestre 1	10	10				



Experimental Design and Statistical Analysis for Next Generation Sequencing

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 10

Directed study: 10

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

none

Programme/contents

Covered topics:

- Next generation sequencing technologies(illumina, long-read sequencing).
- NGS applications (Genome sequencing, Deep mutational scanning, RNA-seq)
- Bioinformatics (Read mapping and filtering for analysis).
- Calculating interpretable scores (fitness, enrichment, fold change) to interpret mutation/gene effects
- Data normalisation
- Statistical tests for differential analysis
- Interpreting errors and noise in data
- Clustering, principal component analysis
- Data visualisation
- Simulations of dynamics

Learning objectives

Next-generation sequencing is emerging as a powerful tool for genotype-phenotype mapping. The objective of the course is to train the students with the analysis of next-generation sequencing for different applications of next-generation sequencing: Genome sequencing, Deep mutational scanning, and RNA sequencing. In the course, the students will learn how to analyse real experimental data, which will help them develop a critical understanding to design high-throughput experiments and interpret data when reading results published in the scientific literature.

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Cell-Free Systems	2.5	Semestre 1	8		12			



Cell-Free Systems

ECTS : 2.5

Semester: Semestre 1

Detail

Lecture: 8

Practical study : 12

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Basic knowledge of molecular biology

Programme/contents

This course class is composed of 8h of lecture and 12h of practical work using the MICALIS cell-free biofoundry. The practical work will include the usage of the biofoundry software platform to maximize protein productivity in cell-free.

Learning objectives

The objectives of this course are to provide students with an understanding of practical aspects developed in the laboratory for the study of cell-free systems and, through concrete examples, illustrate experimental methods to increase protein production in cell-free.

At the end of the course, students will be able to:

- Know the diversity and the different usages of cell-free systems
- Know-how to prepare cell-free systems from cell cultures and cell extracts
- Understand the element required to obtain a functional transcription translation (TX-TL) system.
- Use the automated protocol hosted on the Cell-Free Biofoundry at MICALIS
- Know-how to optimise the productivity of cell-free systems

Overall organisation

Teaching in this EU will include 8 hrs of lectures with simple exercises (TD) given during the courses on specific points and 12hrs of practical work (TP). The practical work will consist of expressing a protein of interest using the Cell-Free biofoundries hosted at the Micalis institute.

Research Internship

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	distanc learn coun
Research Internship	30	Semestre 2							

Research Internship

ECTS : 30

Semester: Semestre 2

Language(s) of instruction

Anglais

Remote teaching

non

Programme/contents

The internship allows students to develop a research project and apply wet and/or dry lab experimental approaches to solve a scientific question.

Learning objectives

The last semester of M2 SSB consists in a 6-month internship of training through research in an academic research laboratory or in biotech companies. It can take place in France or abroad.

The internship is supervised by a confirmed researcher and, at the end, students will become independent and able to

- choose the most appropriate scientific strategies,

- analyse critically the results obtained

- synthesise and present, in oral and written form, a scientific research process and the results obtained.

Moreover, students will integrate a research team and participate to all daily activities, laboratory meetings and conferences.

Overall organisation

The internship lasts 6 months and can take place in an academic laboratory or in the R & D department of a private company, in France or abroad.

At the end of the internship, students write a research report and make an oral presentation that highlights the scientific questions addressed, the experimental models used, and present and discuss critically their results.

Teaching Location(s)

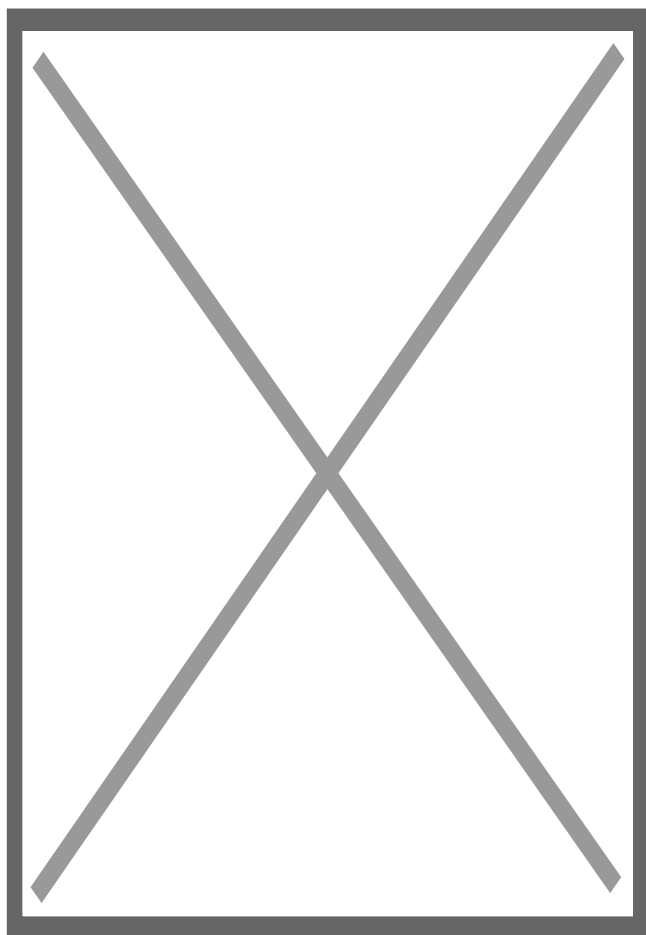
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Academic Partner(s)

Univ. Evry Paris-Saclay, AgroParisTech, CentraleSupélec, Univ Paris-Saclay

Training campus

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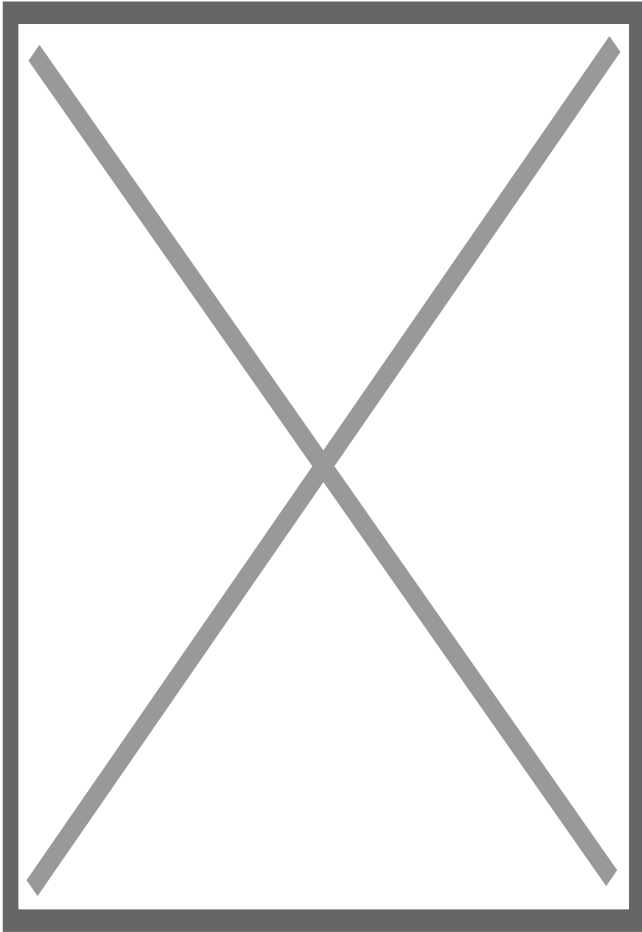
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Student restaurant (CROUS)

Library

Sports facilities

Student residence



Evry

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Sports facilities

Contact

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<http://www.universite-paris-saclay.fr/formation/master/biologie-agrosciences/m2-systems-and-synthetic-biology-ssb>