| | | | | | | |
|---|---|---|---|---|---|---|
| Level: | **MASTER** | | | | | **Year 1** |
| Discipline: | SCIENCE - TECHNOLOGY - HEALTH | | | | | **M1 BS** 60 ECTS |
| Subject: | Biology & Health (Biologie Santé or BS) | | | | | |
| Specialty: | **Molecular Biology Biochemistry (BBM)**<br>**Cellular Biology and Animal Physiology (BCPA)**<br>**Integrative Biology of Plant-Microorganism-Environment Interactions (B2IPME)** | | | | | |
| Student hours: | 166 to 208 hours | 138 to 162 hours | 130 to 172 hours | h | 8 weeks | **480 to 500 hours** |
| | lectures | tutorials | practical courses | integrated courses | internship or project | total |
| Training in: | ☒ French | | ☐ English | | | |

## Contacts:

| Director of the specialty BBM | Director of the specialty BCPA | Director of the specialty B2IPME | Study office |
|---|---|---|---|
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| Connection components: | | | Faculty of Life, Earth and Environmental Sciences (SVTE) |

## Study goals and opportunities:

■ Objectives:

The first year of the Master program (M1) Biology and Health is co-hosted by the Universities of Burgundy and Franche-Comté (UBFC). This M1 is structured around a common core of Teaching Units (TU), specific TUs and optional TUs that students will choose according to their career plans. The objective of the common core curriculum is to enable students to acquire oral and written communication skills (French and English) as well as to develop their knowledge and technical skills in the fields of Biology and Health.
The common core is complemented by specialised TUs with different optional TUs allowing students to pre-orient themselves towards the second year of Masters programs (M2s) in line with their career plans.
Students must validate 10 TUs: 5 common core TUs, 3 specialised TUs and 2 optional TUs to be chosen out

of 7. Each validated TU is equivalent to 6 ECTS (European Credits Transfer System) and the student must obtain 60 ECTS to validate the M1.
An 8-week internship in a research laboratory or company is included in the curriculum during the months of January and February. The internship search is accompanied by 5 workshops offered by the uB Centre for Career Orientation (skills assessment, CV, cover letter, interview, use of social networks). Finally, the majority of Teaching Units have 30 to 40% of practical training, allowing students to acquire technical skills, analyse data independently or in teams, develop their critical thinking and render them active participants in their training.

■ Continuation of studies

The Master 1 Biology & Health allows you to apply for the one of the speciality of Master 2 (M2): M2 SCM, M2 MIB, M2 B2IPME, M2 PNC and M2 EGRP (see below), or for the M2 of other Faculties from the University of Burgundy (Health, Science and Technology...) or M2 from other French or foreign universities.


SCM = M2 Cellular and Molecular Signalling (Research); MIB = M2 Management and Innovation in Biotechnology; B2IPME = M2 Integrated Biology of Plant-Microorganism-Environment Interactions; PNC = M2 Physiology Neuroscience and Behaviour; EGRP = M2P Ergonomics and Professional Risk Management.

- The formation of the M1 Molecular Biology and Biochemistry (M1 BBM) is a first year of the Master BS in adequacy with the M2 SCM and the M2 MIB. The possibilities of reorientation during training exist towards the other M2 of the Biology and Health. In the same way, the M1 BBM also allows you to apply for M2 from other faculties at the University of Burgundy (Health, Science and Technology...) or M2s from other French or foreign universities.

- The M1 Cellular Biology and Animal Physiology (M1 BCPA) is the first year of the Master's degree in Biology and Health, which gives access to several M2s offered within the Biology and Health section: M2 SCM, M2 MIB, M2 EGRP, M2 PNC or offered in other UBFC sections such as M2 Nutrition and Health (M2 NS) or M2 Quality Assurance for Health Products (M2 AQPS). The M1 BCPA also provides access to M2s from other French or foreign universities.

- The M1 Integrative Biology of Plant-Microorganism-Environment Interactions (M1 B2IPME) specialty prepares students for entry into M2 B2IPME and Master 2 programs from other institutions in the field of plant science. Reorientation towards other M2 programs within the "Biology and Health" subject is possible (in particular for M2 MIB).

■ Career opportunities

With a Master 1 and 2 degree there are career opportunities in the public sector and in industry in the biomedical field, the plant/agroenvironmental sector, as well as in biotechnology and health science (Project Manager, Clinical Research Officer, Study Engineer, Business Start-up Engineer, Pre-clinical Study Manager, Quality Engineer, Research Planning Manager, Technical Sales Engineer, Account Manager, Senior Technician, Production Engineer, Regulatory Affairs Officer).

After having obtained a Master 1 and 2 and a PhD, there are additional career options in research and university teaching (researchers, teacher-researchers, research engineers in the public or private sectors).

■ Skills acquired at the end of the training

Command of the fundamental scientific and technical concepts in the sectors concerned by the different specialties of M2: knowledge at the molecular and cellular level of the functioning of living organisms, in the fields of biology and health science, and in the fields of innovation in biotechnology and/or therapeutics.
Ability to apply the knowledge and techniques of different sub-disciplines to a biological problem or issue. Experimentation. Ability to analyze and develop protocols. Ability to plan a scientific project. Knowledge of the essential health and safety rules regarding chemical, biological and radioactive risks in biological laboratories. Communicate: write clearly, prepare communication materials using various techniques (report, slide show, literature review, etc.), and comment on them for an informed or uninformed audience, in French and English.
Scientific and methodological specialisation to master the concepts and tools necessary to exploit recent developments in the fields covered by the various specialties.

■ Skills acquired at the end of the training year

Deepening of the fundamental knowledge acquired in the Bachelor's degree in Biology:

- For the M1 BBM: in cellular biology, molecular biology, biochemistry, physiology in fields focused on health and biotechnology.
- For M1 BCPA: in the fields of physiology, metabolism in relation to the pathology.
- For M1 B2IPME: in the fields of biotechnology, genetics, ecophysiology, plant interactions with their environment at different scales: from molecule to agrosystem.

Development of scientific reasoning based on experimentation and critical analysis of results. Autonomy in research and data analysis, including bibliographic data. Learning to write scientific reports and give oral presentations before a jury or in public. 8 weeks of professional experience, carried out in the form of an

introductory internship in research or in a company, in connection with the student's subsequent projects. Ability to manage a project independently and in a collaborative team environment. Adaptability to different professional contexts, including an international approach. General skills in IT and English leading to a TOEIC type certification.

**Access to the first year of the Master program Biology & Health**

■ On selection

The M1 "Biology & Health" is open to students with a general degree in Biology adapted to the different specialties. Admission of students holding another L3 level degree, in particular a Professional Bachelor, is possible after examination of their application by a pedagogical commission for each course.
As the capacity for each course is set at 15 (BCPA, B2IPME) or 20 students (BBM) per year, a pedagogical commission will examine on file the knowledge previously acquired in the fields of biological sciences and English to validate eligibility for the requested route. In a second stage, admission will be after an oral interview to check the candidates' motivation and skills.
Foreign students who lack one of the French diplomas required for access to the Master program must submit a file to the International Relations Department (see timetable and deadline for submitting a file on the web page relating to this service: section "International" and "Coming to the UB on an individual basis"), even if they are in the process of training in higher education in France at the time of submitting their file.

■ By validation of prior learning or diploma equivalence

A validation of prior learning is required for students coming from a field other than the Bachelor of Biology. Students of French nationality with the required or equivalent diplomas, but obtained abroad, must compile a file for the validation of prior learning (to be obtained from the study office). Their application will be studied according to their university and professional project, their mastery of the French language, and the adequacy of their diplomas with the level and training they wish to integrate.

## Organization and description of studies:

■ Overview of the Teaching Units (TU/UE) of the 3 specialties of the M1 Biology & Health at uB

| | Master 1 Biology & Health 2017-2021 | | | |
|---|---|---|---|---|
| | **BCPA** | **BBM** | **B2IPME** | |
| S1 250h | TU1 - Preparation for Professional Life (50h) | | | 1 |
| | TU2 - Biological Investigation Tools (50h) | | | 2 |
| | TU3 - Scientific Project Management (50h) | | | 3 |
| | TU4 - Cellular and Molecular Signalling (60h) | | | 4 |
| | TU6 - Endocrine Signalling and Health (40h) | TU5 - Advanced Bioinformatics (40h) | | 5 |
| S2 230h-250h | TU21 - Intership & English (20h) | | | 6 |
| | TU22 - Metabolic Physiopathology and Innovative Therapy (60h) | TU23- Biotechnology & Genetic Engineering (60h) | | 7 |
| | | | TU24 - Extraction and Structural Chemistry of Natural Compounds (50h ) | |
| | TU25 - Neurophysiology and Energy Homeostasis (50h) | TU26 - Genomics Transcriptomics Proteomics (50h) | TU27 - Biodiversity and Functioning of Agroecosystems (60h ) | 8 |
| | TU28 - Molecular Pharmacology and Pharmaco-Therapy (50h) | | TU30 - Genome Dynamics- Ecophysiology (60h) | 9 |
| | | TU29 - Bioactive molecules (50h) | | |
| | TU32 - Immunopathology and Immunothérapy (50h) | | | 10 |
| | TU31 - Molecular Regulation of Metabolism by Nutrients (50h) | TU33 - Plant Microorganism Interactions (50h) | | |
| | | TU22 - Metabolic Physiopathology and Innovative Therapy (60h) | | |
| | | TU34 - Molecular Aspects of Genetic Diseases (58h) | | |
| | | TU35 - Bacteriology Virology (58h) | | |
| | 480h | 480-490h | 490-500h | |

■ Exams

The rules applicable to the Bologna Agreement (LMD/BMD) studies are specified in the Common Study Framework posted on the University website
http://www.u-bourgogne-formation.fr/IMG/pdf/referentiel_etudes_lmd.pdf

● ***Examination sessions***

The 1st examination session on the TU of semester 1 takes place at the end of semester 1. These examination dates are available on the UFR SVTE website.

The 1st examination session for semester 2 takes place at the end of semester 2, the examination dates available on the UFR SVTE website. At the end of this session, students validate, or not, the year of M1.

The second session, which covers the TU of semesters 1 and 2 not validated, takes place at the end of June, early July, respecting the two regulatory weeks between the promulgation of the results of session 1 and the start of the examinations of session 2.

For TU 21, part of the evaluation focuses on the content of the internship thesis, the oral presentation and the response to the members of the jury. This evaluation and the follow-up of the internship are counted at the rate of 2 hours per student for each member of the jury of the teaching team.

● ***Validation and capitalization rules***

*General principles:*

COMPENSATION: a compensation is made at the level of each semester. The semester mark is calculated from the average of the marks of the semester's teaching unit assigned coefficients. The semester is validated if the overall average of the TU scores weighted by the coefficients is greater than or equal to 10 out of 20.

CAPITALIZATION: each teaching unit (TU) is assigned a value in European Credits (ECTS). A TU is validated and credited, i.e. definitively acquired when the student has obtained a weighted average of 10 out of 20 or more by offsetting each TU subject. Each validated TU allows the student to acquire the corresponding European Credits. If the constituent elements (materials) of the non-validated TUs have a European Credit value, they can also be capitalized when the scores obtained for these elements are greater than or equal to 10 out of 20.

# TEACHING UNITS:
# TU1: PREPARATION FOR PROFESSIONAL LIFE

ECTS credits: 6
Duration (CM - TD - TP): 18-22-10 Language in which the course is given: French/English

Content, program:
The purpose of this module is to give students i/ a global knowledge of the organization and functioning of a company in the fields of plant and animal biotechnology, pharmaceuticals and biotechnology and ii/ written and oral skills in scientific English. The module allows to become familiar with information searching for a particular scientific project but will also allow to define personal career plans. This module provides an important foundation for any student wishing to pursue their studies with a research or professional M2.

Knowledge of the company (CM 18h; TD 8h; TP 4h)
The social capital, concept and logic of the system, main possible investors (CM 2h, TD 2h)
Presentation of company structures from start-ups to large corporations and operational strategy (CM, 2h)
Comparison between natural and legal persons (TD 2h)
Presentation of the different company structures and examples of company statutes (CM, 2h, TD 2h)
General diagram of how a company operates (TD, 2h)
Seminars on business, research and issues in life sciences (CM 12h)
Visits to companies or research centres (TP 4h)

English (TD 14h; TP 6h)
Written training:
- Review/acquisition of 6 grammar themes especially useful for the use of English in the scientific environment (present and past tense, interrogative forms, passive tense, uncountable nouns, quantifiers).
- Review/acquisition of 3 lexical themes (plurals of Latin/Greek origin, derivatives of nouns/verbs, false friends, linking words). - Knowledge of university systems in Anglo-Saxon countries. - Writing ae CV in English. - Learning how to write letters and e-mails in English. - Progressive acquisition of the scientific vocabulary common to the different biological specialities. Dissemination of knowledge in the scientific community: reading and identification of the linguistic and discursive specificities of a research article.
Oral training:
- Learning oral communication techniques using Powerpoint support (how to introduce yourself, get in touch with the audience, say what training you are following, introduce a topic, present a plan, develop a topic, conclude and invite questions, etc.). - Presentation of i/ a team of famous biologists and their discoveries or ii/ a current method in one of the biological specialities. - Introduction to the individual interview in English. - Abstract/synthesis practice by a student following the presentation. - Practice of questions and answers in the whole group.

Skills acquired:
At the end of the course, students will be able to analyse a company's structure globally by identifying its origin, management board, profession and general situation. Students will also learn about the steps and tools required to develop contact or collaboration with companies. A comprehensive vision of the company's operational strategy and research seminars will allow students to better understand the job opportunities available after their scientific training. The skills acquired in English will allow students to pursue an international career.

# TU2: BIOLOGICAL INVESTIGATION TOOLS

ECTS credits: 6
Duration (CM - TD - TP): 16-10-24
Language in which the course is given: French

Content, program:
The purpose of this module is to give students the theoretical and practical knowledge of the tools used to study different molecules (proteins, nucleic acids, second messengers...) in a given biological context (oxidative stress, apoptosis, signalling...). This module provides an important foundation for any student wishing to pursue their studies with a research or professional M2.

CM (16h):
1- Electromagnetic waves (3h) - UV spectroscopy, visible, Infrared - absorption and emission mechanisms - intrinsic, extrinsic chromophores - Applications: UV and visible light spectrophotometric measurements. 2- Fluorescence (8h) Principles - excitation and emission spectra - intrinsic and extrinsic fluorophores - fluorescence transfer - Applications: use of fluorescent probes for - the determination of free intracellular calcium (Indo, Fura, aequorin, chameleon probes), - the subcellular localization of proteins by fusion with PFM, - the expression of reporter genes using different types of fluorescent or luminescent proteins, - protein/protein interactions (FRET and BRET techniques), - the detection of apoptotic processes - the measurement of membrane fluidity (FRAP) 3- Radioactivity (3h) - radionuclides and various radioactive emissions - decay processes, radioactive decay - examples of the use of radioisotopes in biology (scintillation counter, autoradiography and phosphorimager) 4- Quantitative Real Time PCR (2h)

TD (10h):
Exercises for application of HPLC techniques, confocal microscopy (PFM variants and derivatives), spectrophotometry, spectrofluorimetry and radioactivity.

TP (24h):
Topics covered according to the M2 pre-orientation chosen: practical work allowing the use of techniques applied to plant and animal physiology and biochemistry.

Study of isobestic chromophore points - Biotinylation of proteins and dosage/detection of biotin by spectrofluorimetry and chemiluminescence - Research of optimal conditions for HPLC separation of small biological molecules - Fluorescence microscopy.

Skills acquired:
At the end of the course, students will be familiar with the principles of and will be able to use different physico-chemical, biochemical and biotechnological techniques applied to the study of macromolecules. They will also understand laboratory safety concepts regarding biological and radioactive risks. They will also be aware of some possible applications of these techniques for research and industry in the fields of Biology and Health.

# TU3: SCIENTIFIC PROJECT MANAGEMENT

ECTS credits: 6
Duration (CM - TD - TP): 16-30-4
Language in which the course is given: French

Content, program: The purpose of this module is to give students a global knowledge of project management (from literature review to statistical analysis) both in a public research environment and in a company. This module provides an important foundation for any student wishing to pursue their studies with a research or professional M2.

Literature review (TD 10h, TP 4h):
The objective is to teach students to write a literature review using bibliographic databases and reference management software combined with word processing. Understanding specialized research vocabulary, using the appropriate tools to search for information and structure a properly illustrated report will enable students to develop an integrated scientific mini-project.

Project Management (CM 10h, TD 6h):
History and logic of project management (CM 1 h). Awareness of intellectual property issues (CM, 3h). The different types of projects in terms of organization and management (CM: 2h). Project management: the concept, the vocabulary and how to create the virtuous triangle: cost, deadlines and quality (CM, 2h). Compiling a list of duties (TD: 2h). Organization of meetings with the QQOQCP tool and mind mapping (TD: 2h). Planning: principles, tools and implementation with the Gantt project tool (TD: 2h). Examples of setting up an industrial or scientific project (european, national, regional in public/private partnership...CM : 2h)

Experimental design and bio-statistics (CM 6h, TD 14h):
Reminders of the main concepts used in statistics (CM, 2h)
Impact of the design of the experiment on the statistical analysis of the results (CM, 2h)
The different existing statistical tests and their limits of use (which test to choose according to the hypothesis to be tested? CM, 2h)
Exercises in the application of statistics for the analysis of results of biological experiments (TD 6h). Some tutorials will directly use TP results obtained by students in other TUs and will be analysed in the computer room with the help of user-friendly open access software (TD 8h).

Skills acquired:
At the end of the course, students will be able to produce a literature review using reference management software, formalize the specifications and establish a general project plan. This will include the design of experiments in connection with the statistical analysis of the results.
Students will also be able to identify which steps and tools are essential for the successful completion of a project. They will also be able to analyse a situation by reviewing the various major points in the management of a project.

# TU4: CELLULAR AND MOLECULAR SIGNALLING

ECTS credits: 6
Duration (CM - TD - TP): 34-6-20
Language in which the course is given: French

Content, program: The pedagogical objective of this module is to provide students with a global knowledge of the different cellular and molecular signalling processes existing in prokaryotes and eukaryotes (animals, plants, yeasts...). This module provides an important foundation for any student wishing to pursue their studies with a research or professional M2.

CM (34h):
- Introduction presenting the interdependence links between the extracellular environment, cell surface and intracellular signalling and the consequences arising from them, such as cell differentiation and death.
- The different types of signals: hormones and other informative molecules.
- The membrane environment: membrane fluidity and lipid micro-domains.
- Membrane receptors: classification, identification and identification criteria, techniques for measuring ligand receptor affinities, activation and desensitization mechanisms.
- The second messengers: cAMP, calcium, nitric oxide, reactive forms of oxygen, lipid mediators and their cellular targets.
- The elements of the transduction pathways: G proteins, phospholipases, protein kinases and phosphatases; examples of signal transduction in mammals and plants.
- Signalling and cell proliferation/death, cell cycle control and cell adhesion.

TD (6h):
Exercises related to the courses, processing and analysis of data from the practical work.

TP (8h):
Study of molecular and cellular signalling pathways triggered by biotic or abiotic stresses in animal or plant cell lines: cell culture, immunofluorescence cell imaging, subcellular fractionation and immunoblotting, flow cytometry, HPLC metabolite analysis.

Skills acquired:
Students will acquire important knowledge and skills in the field of signalling and cellular communication. This knowledge is essential for a detailed understanding of physiological processes such as those addressed in many research or professional M2s. In addition, the knowledge acquired will cover both animal and plant physiology, microorganisms, offering students a broader vision of cellular signalling/communication concepts.
Students will also be able to produce a practical work report using all the tools developed in "Project Management" and "Preparation for Professional Life". This will include the design of experiments, statistical analysis of the results and the writing of a clear, synthetic and properly illustrated scientific report.

# TU5: ADVANCED BIOINFORMATICS

ECTS credits: 6
Duration (CM - TD - TP): 10-18-12
Language in which the course is given: French
Content, program:
The purpose of this module is to give students an advanced knowledge of the bioinformatic analyses required by any biologist. This module provides an important foundation for any student wishing to pursue their studies with a research or professional M2.

CM (10h):

Genomic annotation and gene prediction programs (2h)
Multiple alignments of biological sequences, patterns and protein domains (4h)
DNA Databases and ENCODE Project (2h)
Three-dimensional structure of biomolecules: analysis and prediction of secondary and tertiary protein structures (2h)

TD (6h):

Using genomic annotation software (2h)
Learning to use web servers and multiple sequence alignment software: sequence comparison and multiple alignments (4h)
Design and analysis tools for protein patterns and 3D structure (4h)
Principle of *in silico* cloning of a DNA fragment with open source software (4h)
Bioinformatics tools for the analysis of quantitative PCR data (4h)

TP (12h):

Virtual cloning of a DNA fragment to achieve heterologous expression of a protein fused to a tag (4h).
TP design and analysis of protein patterns and 3D structure analysis (4h)
Assessment of acquired skills (4h)

Skills acquired:
The bioinformatics tool will allow students to develop advanced skills to: analyze nucleic and protein sequences, study proteins using a structural biochemistry (3D) approach, perform *in silico* cloning to prepare heterologous expression of a mutated or labelled protein, study transcript expression by analyzing raw data from quantitative PCR.

# TU 6: ENDOCRINE SIGNALLING AND HEALTH

ECTS credits: 6
Duration (CM - TD - TP): 22-8-10
Language in which the course is given: French
Content, program: The objective of this TU is to provide students with a solid foundation for

CM
- The endocrine system: glands, cells, hormones
- Mechanisms of hormone action,
  Endocrine and paracrine action
  Hormone receptors
  Nuclear receptors
  Signalling pathways
- Integrations with other systems
- The hypothalamic-pituitary system: neuroendocrinology
- Growth, development: hormones
- Cancer and endocrinology
- Connections with the immune system

TD
Non-glandular hormones
Diabetes and autoimmunity
Hormones and biological rhythms
Hormones and muscles

TP
Metabolic and mechanical response to hormones such as the uterus
Metabolic consequences of hormonal over- or under-expression: glucocorticoids

Skills acquired:
Solid knowledge of the molecular, cellular and physiological aspects of endocrinology. Through an integrated approach, this TU allows the acquisition of methods for the analysis of physiological and physiopathological mechanisms in relation to endocrinology and the command of physiological tools and experimental methods.

# TU21: INTERNSHIP & ENGLISH

Title TU21: Internship & English (STA)

Duration of the internship: 8 weeks (French/English)

English (CM - TD - TP): 0-16-4 (English)

Content, program:
Internship (8 weeks): the 8-week internship is carried out in January & February. The internship site is conducted in a company or research laboratory (private or public) in France or abroad in the general field of Biology-Health. This internship is intended to enable students to approach the professional world of public (CNRS, INSERM, INRA or partners) or private laboratories (e.g. research and development laboratory of the pharmaceutical, biomedical, agri-food industry or local start-ups) and to confirm their choice towards a Master 2 research or career path. The internship is the subject of an agreement between the University of Burgundy and the student's Host Company or laboratory.
The search for an internship is done by the student. This is an individual procedure requiring attendance of various workshops to prepare a CV, a cover letter, and the interview, in coordination with the Training and Career Orientation Centre. The internship is described in a twenty-page written report which must comply with the terms of the instruction sheet provided by the teacher in charge of the internships and must be submitted within the prescribed time limits.
Each student will have to make an oral presentation to present their internship and answer the jury's questions. The jury gives each student a final mark taking into account all the student's work (written, oral report, answers to the jury's questions, assessment by the tutor).

English (TD 16h, TP 4h):
Written training:
I. Review/acquisition of grammar topics especially useful for the use of English in scientific contexts (compound names, articles a/the/Ø, modals, double verbal constructions). II. Writing a summary of the internship carried out in January-February, following the conventions of a scientific abstract.
Oral training:
I. Individual presentation of the laboratory or company where the student would like to do his M2 internship using a Powerpoint support. II. Training in listening comprehension of native speakers in the language laboratory from audio tapes (recorded on BBC 4 Science). A preparation for a certificate in English (TOEIC) is offered to all M1 Biology Health students in the second semester.

Skills acquired:
The internship provides a first professional experience to guide the student in his future orientation. The written reports (internship plus literature review) are intended to provide the necessary background for this type of activity, which is common in many sectors of Biology & Health. The oral presentation is also formative for the different sectors of Biology & Health. Indeed, oral presentations of the progress of research or other work are common in public or private professional environments. In parallel, this TU aims to develop independence in writing, speaking and understanding English. The student can also prepare to pass the optional TOEIC certificate at the end of his M1 year.

# TU22: METABOLIC PHYSIOPATHOLOGY AND INNOVATIVE THERAPY

ECTS credits: 6
Duration (CM - TD - TP): 28-12-20
Language in which the course is given: French

Content, program: The objective of this TU is to provide students a solid basis related to the etiology of several metabolic diseases associated to overweight, ageing and the environment by addressing therapeutic aspects. This TU is intended to raise students' awareness of topics of interest to local research teams and therefore likely to host them in M2R and doctoral studies.
I- Physiopathology of obesity and diabetes
(a) Epidemiology of obesity and type I and type II diabetes. Clinical parameters and altered markers.
b) Metabolic deregulations in key organs of energy metabolism: Insulin resistance; dysfunction of atrophied adipose tissue; molecular mechanisms of lipotoxicity and glucotoxicity; reticulum stress; inflammation; autoimmunity; mitochondrial dysfunction; role of intestinal flora. (c) Complications: Vascular and cardiac diseases; hypertension; retinopathy; atherosclerosis.
The pathophysiology of food intake during obesity will be treated in the TU "Neurophysiology and homeostasis".
II- Age, environmental and genetic diseases
(a) Neurodegenerative diseases, (b) Genetic predispositions, epigenetic factors (diet, endocrine disrupters...) and pathologies (c) and (d) Biological rhythms.

TD: Study of recent and innovative therapeutic approaches through the analysis of publications:
E.g. Treatment of obesity and diabetes; Metabolic consequences of bariatric surgery; Stem cells, cell therapy and gene therapy or other current topics.

TP: Study of the deregulations of carbohydrate and lipid metabolism induced by an obesogenic diet in mice. Measurement of glucose tolerance and insulin sensitivity (OGTT, ITT) surgical techniques, organ sampling, analysis of blood parameters (glucose, triglycerides, cholesterol, lipoproteins), determination of liver triglycerides, measurement of activity and expression of neoglucogenesis and lipogenesis enzymes. Calculations, interpretations and statistical analysis of all results. Report in the form of an oral scientific communication.

Skills acquired: By following this TU and considering the animal physiology courses offered during the Bachelor studies, students will acquire a solid knowledge of the cellular and molecular mechanisms responsible for metabolic pathologies. They will also be informed about current and future therapeutic strategies. In addition, the practical laboratory work will raise awareness of the use of mouse models and techniques commonly used in research to study metabolism.

# TU23: BIOTECHNOLOGY AND GENETIC ENGINEERING

ECTS credits: 6
Duration (CM - TD - TP): 24-12-24
Language in which the course is given: French
Content, program:
The purpose of this module is to give students an advanced knowledge of Genetic Engineering applied to Biotechnology. This module provides important foundations for any student wishing to pursue their university studies with a research M2, or professional M2.

CM (24h):
Definition and/or reminders, basic techniques: manipulation with restriction and modification enzymes, cloning strategy. Biological properties of plasmids, cosmids, YAC, BAC and other specialised vectors (2h). Genome labelling, promoter trapping (2h). Spatial and temporal analysis of genes (reporter genes, in situ hybridization,...) and notion of promoter (constitutive, inducible, cell/tissue/organ/organism -dependent...) (2h). Direct gene transfer (animal cells) by chemical liposomes - stable vs. transient transfection, transactivation test on natural promoter, on isolated response element (2h). Gene transfer to cells and embryos by addition or substitution (homologous recombination); retrovirus/adenovirus, Cre/LoxP system and conditional transgenesis (inducible Cre/LBD mutation of the E2 receptor) (2h). Animal transgenesis by random insertion (3h). siRNA, shRNA, miRNA: general and technical considerations for optimal use (3h). Indirect gene transfer via biological vectors (Agrobacteria, viruses...) in plants and fungi (2h30). Stable and transient transformation in plants and applications in varietal improvement. Transformation of fungal cells (*Saccharomyces cerevisiae, Pichia pastoris*, filamentous fungi...) and industrial (fermentation) or medical applications. Overexpression, inactivation of a coding sequence (Virus-induced gene silencing), reverse genetics, natural mutagenesis (somaclonal variation), or induced mutagenesis (ionizing, chemical, insertion) and selection of plant transformants (2h30). Production of recombinant proteins in animal cells, plant cells, yeasts, prokaryotes and insect cells (3h).

TD (12h):
Search for primers for PCR, subcloning and ligation, directed mutagenesis, stable and transient transfection. Mice or transgenic plants, knock-outs, examples of gene therapy. Use of polymorphic markers (RFLP, microsatellites, VNTR) for genetic identification. Methods for studying DNA-Protein interactions and functional tests in transfection.

TP (24h):
Cellular transactivation test (reporter activity "Luciferase") on natural promoter or wild type or point-mutated response elements. Transformation of plant cells and/or yeasts to achieve transient/stable expression of a protein of interest.

Skills acquired:
Students will have developed skills in genetic engineering to practice multiple recombinant DNA techniques in order to carry out different expression strategies for biotechnological purposes.

# TU24: EXTRACTION AND STRUCTURAL CHEMISTRY OF NATURAL COMPOUNDS

ECTS credits: 6

Duration (CM - TD - TP): 10-0-0-40

Language in which the course is given: French

Content, program:
The objective of this teaching is to train the student in methods of extraction, isolation and identification of natural substances contained in plants.

-Preparative liquid chromatography fractionation techniques (different supports, flash chromatography, liquid vacuum chromatography, low, medium and high pressure liquid chromatography); fractionated crystallization; fractionated distillation

-Characterization of compounds - UV, IR, NMR spectrometry of proton, carbon... Homo and heteronuclear correlations - Mass spectrometry: IE, IC, FAB, ES, MS-MS, HR SM...

-Examples illustrating the importance of natural products in the field of pharmaceuticals (alkaloids, flavonoids, terpenoids/steroids)

The practical work involves a phytochemical study of the isolation of active ingredients belonging to the class of triterpenic glycosides.

Skills acquired: Acquisition of classical and innovative methodologies in the field of natural substance chemistry (extraction, isolation, structural determination)

# TU25: NEUROPHYSIOLOGY OF ENERGY HOMEOSTASIS

ECTS credits: 6
Duration (CM - TD - TP): 30-12-8
Language in which the course is given: French

Content, program:
Course (CM, 30h):
The aim of this TU is to give students a thorough knowledge of the involvement of different parts of the brain in the modulation of energy homeostasis by neural and peripheral signals. The topics covered are in particular:
- neural circuits, interrelationships between different neuron populations and glial cells, factors involved in controlling food intake and energy homeostasis
- neurogenesis and neuronal plasticity, role of nutrients, hormones and cytokines
-neurobiology of olfaction and taste, post-ingestive metabolic signals, neural glucoreceptors, catecholaminergic reward system.
- mechanisms shared with neurodegenerative diseases.

Presentations (TD 12h):
The TDs will be conducted in the form of presentations by students on topics proposed by teachers. The themes will be treated in complementarity with the courses in order to deepen and broaden knowledge.

Effects of glycopenia on neurotransmitter metabolism (TP 8h):
The students will administer 2-deoxyglucose in mice and then study food intake for 12 hours. After killing the animals, they will measure activity of enzymes involved in the synthesis of serotonin and catecholamines in different areas of the brain.

Skills acquired: At the end of the course, students will have a solid knowledge of the cellular and molecular mechanisms in central nervous system involved in the regulation of energy homeostasis (food intake and effects on peripheral organs).

# TU26: GENOMICS, TRANSCRIPTOMICS, PROTEOMICS

ECTS credits: 6
Duration (CM - TD/CI - TP): 22-16-12
Language in which the course is given: French

Content, program:
The purpose of this module is to provide students with an important foundation in the use of "omics" technologies (genomics, transcriptomics, proteomics, metabolomics,...) and the analysis of metadata generated to study a complex biological process in a global way, and without a priori.

CM (22h):
- Genomics: new high-throughput sequencing techniques, detection of polymorphisms, molecular diagnosis of diseases (2h)
- Transcriptomics analysis: from sample to data analysis (3h)
- Proteomics: Mass spectrometry, 2-D techniques, large-scale identification of proteins and their post-translational modifications, quantitative proteomics (8h)
- Protein, Interactomics and Metabolomics chips (4h)
- Genome interaction with transcription factors, Chip on Chip (4h)
- Introduction to the practical work - (1h)

TD (4h):
- Literature reviews using genomics, transcriptomics, proteomics and metabolomics techniques (5h)
- Transcriptomics: data processing and analysis of microarray results, correlation coefficient analysis, dendrogram construction, statistical testing, metabolic pathway exploration (8h)
- Proteomics: Identification of proteins by analysis of PMF and MS/MS mass spectrometry data (3h)

TP (12h):
- Analysis and comparison of post-translational protein modification profiles and/or validation of transcriptomic data by qPCR analysis of transcripts on a wild genotype compared to a mutated genotype.

Skills acquired: Students will become familiar with the scientific approaches using these "omics" technologies to analyze complex biological processes at different levels (DNA, mRNA, proteins, metabolites) while developing the ability to analyze metadata.

# TU27: BIODIVERSITY AND FUNCTIONING OF AGRO-ECOSYSTEMS

ECTS credits: 6
Duration (CM - TD - TP): 32 - 12 - 16
Language in which the course is given: French / English

Content, program:

CM: 32h
I- Introduction to agronomy. II- Functioning of agro-ecosystems. Climate: bioclimatology and energy transfer in ecosystems. Soil: factors of pedogenesis, soil chemistry, soil physics, biogeochemical cycles. III- Biodiversity of agro-ecosystems. Plant ecology and diversity: perennial, annual crops, meadows, weeds. Ecology and animal diversity: soil fauna. Ecology and microbial diversity: bacteria, archaea, fungi. Cultivation-based and molecular methods for the analysis of the diversity and functions of soil microbial communities. IV- Links biodiversity versus functioning and diversity of ecological interactions.

TD: 12h
Comparative analysis of energy flows in an ecosystem and an agrosystem. Sampling plan: preparation for TP. Microbial communities. Plant and animal communities.

TP: 16h
Excursion: presentation of a teaching farm, sampling of fauna, flora, microorganisms.
Methods for the analysis of microbial communities.

Skills acquired:
This module aims to provide the student with the ability to understand all the life forms that an agroecosystem hosts. It will also be able to understand communities in terms of functional diversity, based on the biological characteristics of the species.
In terms of the functioning of the agroecosystem, the student will have the necessary knowledge to characterize the abiotic environment, in particular climate and soil.
The students will be familiar with the calculation methods used to monitor energy transfers in an agrosystem and will be able to compare its functioning with that of more natural ecosystems. He/she will master the concept of the biogeochemical cycle and understand the role of microorganisms in this context, which will enable him/her to develop skills in the ecological diagnosis of agroecosystems and to consider solutions to pollution problems caused by agricultural practices.
Finally, it will be able to establish links between the observed diversity and ecosystem functioning, based on theoretical work. This will enable developing arguments on the need to conserve biodiversity within agro-ecosystems.

# TU28: MOLECULAR PHARMACOLOGY AND PHARMACOTHERAPY

ECTS credits: 6

Duration (CM - TD - TP): 22-12-16
Language in which the course is given: French

Content, program:
The purpose of this module is to provide students with advanced and up-to-date knowledge of pharmacology and pharmacotherapy. This module provides an important foundation for any student wishing to pursue their studies with a research or professional M2.

CM (22h):
- To deepen knowledge of pharmacology and pharmacotherapy
- Cellular targets in drug therapies (examples: cancer, neurodegenerative diseases...)
- Chemotherapies
- Pharmaceutical biotechnology and innovative therapy (gene and cell therapy)
- Therapeutics: from the concept to the proper use of health products
- Introduce students to health product research and development strategies

TD (12h):
- tutored project and article analysis in the field of pharmacotherapy
- Introduce students to health product research and development strategies

TP (4h):
- Monitoring of drug metabolism and analysis of metabolites by HPLC.

Acquired skills: Students will have developed skills related to:
- Drug therapy concepts
- The molecular targets of the drug and the associated signalling pathways
- Understanding of health product research and development strategies.

# TU29: BIOACTIVE MOLECULES

ECTS credits: 6
Duration (CM - TD - TP): 8-0-42
Language in which the course is given: French

Content, program:
This TU brings together several disciplinary fields (chemistry, biochemistry and microbiology) and is aimed at an audience of students with general undergraduate knowledge in these fields. Theoretical and technical knowledge will be refreshed to enable all non-specialist students in these disciplines to follow the TU.

The objective of this TU is to present to students, within the framework of collaborative work between chemists, biochemists and microbiologists, various classes of molecules with therapeutic properties. During practical work sessions, students will prepare, by synthetic, hemi-synthetic or extraction methods, molecules whose activity will be tested on cell cultures. Molecules with either anti-cancer or antibiotic properties will be studied in particular.

CM (8h):
- Example of the preparation of antibiotic and anticancer molecules.
- Example of plant molecules with antitumor activity: ellipticine, vinblastine, vincristine, taxol.
- Example of antimalarial plant molecules
- Research of plant molecules active against the AIDS virus. The discovery, structure and mode of action of these molecules and some of their derivatives are discussed.
- Antibiotic-producing microorganisms. Physiology and growth pattern. Mode of action and resistance systems.
- Microorganisms and antimicrobial agents

TP (42h):
- Preparation by extraction, hemi-synthesis or total synthesis of molecules with antibiotic or anti-cancer properties. Spectroscopic analysis of molecules (NMR, MS, IR, UV).
- Determination of product efficacy by cell count. Cytotoxicity tests (MTT, XTT, crystal violet) based on the measurement of mitochondrial activity.
-Testing of antimicrobial molecules on different bacterial genera under different physiological conditions (planktonic or biofilms).

Skills acquired:
Students will have developed the ability to synthesize, hemi-synthesize, and extract chemical molecules with interesting biological properties discovered after screening tests on cancer cells and bacteria.

# TU30: GENOME DYNAMICS- ECOPHYSIOLOGY

ECTS credits: 6
Duration (CM - TD - TP): 28-16-16-16
Language in which the course is given: French/English

Content, program:
Main topics covered in Genetic Innovation:
1. Genome dynamics
    Role of transposable elements
    Polyploidization and gene duplication
    Specificities and dynamics of chloroplastic and mitochondrial genomes
    Genesis and heredity of epigenetic changes
2. Genetic diversity and plant breeding
    Genotype - phenotype relationship (qualitative and quantitative variations)
    Genotype - environment interaction
    Reproduction modes and selection schemes
    Contribution of molecular markers
    Pangenomic association study

Prerequisites: Basic knowledge of gene structure, expression, regulation and genome organization.

Main topics covered in Ecophysiology:
1. Integrated functioning of plants with potential, notions of threshold, constraint and stress.
2. Concepts of plasticity and adjustment, escape, avoidance and tolerance strategies, adaptation vs. acclimation of plants to their environment at different organizational levels (from cell to organism, to populations)
3. Deciphering functional plant responses to particular environmental traits, including water (from cell level to macroscopic level), saline (cell level) and nutrient (metabolism and fitness) constraints.

Prerequisites: Basic knowledge of plant metabolism and growth and plant physiology.

The objectives of the TDs and TPs will be to describe and use integrative analyses that combine genetic and ecophysiological approaches to understand and predict the behaviour of plants exposed to various types of abiotic stress.

Skills acquired: Discover the drivers of genetic innovation in plants. Understand what genetic and genomic concepts and methodologies can contribute to the development of crop varieties that meet human needs (food, environment, etc.).

Use and learn to connect all the knowledge acquired in order to be able to address research questions in the field of plant responses to various environmental traits. Understand the integrated functioning of the plant in relation to its environment.

# TU31: MOLECULAR REGULATION OF METABOLISM BY NUTRIENTS

ECTS credits: 6
Duration (CM - TD - TP): 28-12-10
Language in which the course is given: French

Content, program:

CM:
1- Regulation of the cell cycle by lipid nutrients, via their intervention in cell signalling. Pharmaconutrient concept. Importance of exogenous/endogenous fatty acids in the modulation of cellular activity. Nutrients as growth factors (polyamines and fatty acids) - their role in the evolution/regression of different diseases (carcinogenesis, immunity...)

2- Regulation of gene expression by nutrients. Transgenic animal models. Peer recombinations. Perspectives/consequences of the application of transgenesis from a food, ecotoxicological and environmental perspective

3- Regulation of nuclear receptors (peroxisome proliferator-activated receptors, PPARα, β, γ) by synthetic ligands (drugs) and nutrients (fatty acids). Importance of PPARs in normal and cancerous cell differentiation and proliferation.

TD:
The TDs will focus on the study of the regulation of gene expression by nutrients, and will consist of an analysis of recent publications in this field.

TP:
Regulation of gene expression in lipid metabolism by AGn-3. Study on in vivo or in vitro models according to experiments in progress in TU teachers' laboratories.

Skills acquired:
Knowledge of gene/nutrient interactions and regulations

# TU32: IMMUNO-PATHOLOGY AND IMMUNO-THERAPY

ECTS credits: 6
Duration (CM - TD - TP): 20-18-12
Language in which the course is given: French

Content, program:
CM (20h):
- Reminders of the basics of immunology
- Antibody design and therapeutic antibodies and applications
- Studies of immune system and cancer relationships, targeted cancer immunotherapies
- Prions, viruses and cell tropism: HIV and AIDS, influenza, emerging viruses, development of new vaccines...
- Immunotherapy for autoimmune diseases

TD (6h):
Preparation and correction of exercises based on scientific articles, on various themes - Presentations on various current themes of recent articles in the scientific literature. Each student presents an article, and a debate is proposed following the presentations.

TP (12h): Study of immune cells:
Preparation and characterization of immune cell subpopulations in zebrafish (observations of macrophages and neutrophils in transgenic larvae of zebrafish) and mice. Activation of immune cells and induction of cell death of tumor cells.
Analysis of immune cells by flow cytometry.
Demonstration of the immunomodulatory effect of chemotherapy.

Skills acquired:
Mobilization of knowledge in immunology and molecular biology, recall of basic knowledge in virology, oncology and on different pathologies.
Deepening of knowledge in preclinical immunology, with applied perspectives.
Introduction to critical thinking on research articles, and on examples of new therapies (immunotherapies adapted to pathologies, protocol design, preclinical tests, animal models)

# TU 33: PLANT MICROORGANISM INTERACTIONS

ECTS credits: 6
Duration (CM - TD - TP): 22-8-20
Language in which the course is given: French/English

Content, program:
The purpose of this module is to provide students a global knowledge of the different types of plant microorganism relationships (mutualism versus pathogenesis, gradient from parasitism to mutualism) and the underlying mechanisms. Consequently, this module provides important scientific foundations for any student wishing to pursue his or her studies through an M2 (research or professional) in relation to agroecology.

Pathogenesis/defence (10h CM, 4h TD, 12h TP)
This section aims to define general concepts related to plant pathology and plant resistance (immunity). The different types of pathogens (including viruses) and their infection strategies (2h CM). Plant defence reactions (8h CM): recognition (perception) and early signalling (2h CM), late signaling (phytohormones; 2h CM), ontogenic resistance: difference in *Botrytis* resistance between green and mature berries (2h CM) and induced resistance (2h CM). Cost/benefit aspects of induced resistance and factors impacting the level of resistance (genotype, nutrition, environmental factors) (2h TD). Methodology associated with resistance assessment: discussion on the development of innovative and relevant protocols (2h TD). Application of the principles: in the *Arabidopsis / Botrytis* interaction - comparison of sensitivity / resistance levels in different plant genotypes (wild / mutant) with characterization of certain enzymatic activities related to resistance (12h TP)

Mutualism (12h CM, 4h TD, 8h TP)
This section aims to define the general concepts relating to mutualism and in particular to endomycorrhizal symbiotic interactions. Mutualism concepts. The different types of plant-microorganism interactions (2h CM). Ecological and evolutionary aspects of plant/microbe symbioses: evolution of mycorrhizae (evolutionary history, phylogeny, mutualism/parasitism gradient, links with evolution of nodular symbioses) (2h CM); Ecology of mycorrhizae (2h CM) and evolution of biotrophic/necrotrophic/saprotrophic fungi genomes (2h CM). Interest of mycorrhizae for plant nutrition: sampling, transport and exchange of nutrients - concrete case studies (2h CM). Notion of common mycelial networks and communication between plants via the hyphal network (2h CM + 2hTD). Research article presentations on vine mycorrhization (2h TD). Knowledge application: evaluation of the mycorrhization of vines - intensity of mycorrhization and diversity (8h TP).

Skills acquired:
At the end of the course, students will be able to understand the concepts of how plants respond to their biotic (microbial) environment and the underlying mechanisms.