Courses content of the semester 1 at URCA

Course title: Disciplinary reinforcement in chemistry or biology

Key words	Fundamentals, general chemistry, organic chemistry, chemical bond, electronegativity, thermodynamics, equilibria, oxido-reduction, acids and bases. Nomenclature, stereochemistry, electronic effects, reactions in organic chemistry. Biochemistry, microbiology, enzymology, process engineering, vegetal biochemistry, molecular biology
Aims	This course is dedicated for biology and chemistry students and aims to give them basic knowledge in chemistry or biology.
Content	**Lectures** - Disciplinary reinforcement in chemistry: General chemistry: chemical bonding, electronegativity, thermodynamics (change of state, mixtures), chemical equilibria, oxido-reduction, acids and bases (pH calculations) Organic chemistry: nomenclature, stereochemistry, electronic effects, organic functions and reactions, introduction to 1H NMR **OR** - Disciplinary reinforcement in biology: Microbiology (eukaryotic / prokaryotic cells, bases of microbial metabolism), molecular biology (genome and its expression) Enzymology: enzymes classification, characteristic, kinetics, in industries, selection-production-purification, formulation (immobilization), engineering **Tutorial class** - Disciplinary reinforcement in chemistry: Step by step explanation of basic chemistry exercises **OR** - Disciplinary reinforcement in biology: Enzymology: focus onto cellulases; microbiology-molecular biology: examples of approaches
ECTS	**3**
Skills	Knowledge and understanding For a passing grade the student must: - Strengthening of the fundamentals of general and organic chemistry or the fundamentals of microbiology, molecular biology and enzymology. - Develop a critical analysis of experimental approach (research article and experimental design) and expose a critical view of experimental results.
Module Coordinator(s)	Marie-Charlotte Belhomme
Teaching staff	Sandrine Bouquillon, Marie-Charlotte Belhomme, Caroline Rémond, Harivony Rakotoarivonina
Language of instruction	English
Nb hours of lectures	25 h

Nb hours of practical work	
Nb hours of tutorials	10 h
Nb hours of personal work	15 h (preparation of tutorial)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	Articles from the scientific literature
Prerequisites	Basic general knowledge in chemistry or in biochemistry
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1**: Written exam : /100 **Session 2:** Written exam : /50 Oral presentation : /50

Course title: Physiology of plant development

Key words	Plant reproduction, seed, germination, flower and fruit development
Aims	Gain knowledge on plant reproduction from the flower and fruit development to the seed development and germination in Angiosperms
Content	**Lectures**: physiology of flowering process, pollination, fertilization and both fruit and seed maturity; impact of internal and external factors on reproduction process **Tutorials**: role of phytohormons, light and temperature from initiation of flowers, flower development to fruit maturity and on seed growth. **Practical courses**: biochemical characterization of fruit and seed maturity (sugars, acids and proteins quantification)
ECTS	**3**
Skills	<u>Knowledge and understanding</u> For a passing grade the student must master the following topics: • Flower and fruit development • Seed germination and plant development • Induction of reproduction <u>Competences and skills</u> For a passing grade the student must • analyse scientific papers relevant to plant physiology • design and analyse an experiment <u>Judgement and approach</u> For a passing grade the student must • develop a critical analysis of experimental approach (research article and experimental design) and expose a critical view of experimental results
Module Coordinator(s)	Florence Fontaine
Teaching staff	Florence Fontaine, Angélique Rat
Language of instruction	English

Nb hours of lectures	12h
Nb hours of practical work	4h
Nb hours of tutorials	4h
Nb hours of personal work	25h (preparation of courses, tutorial and practical work, writing of technical report, searching and learning of course's complements in scientific literature)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	Articles from the scientific literature and books
Prerequisites	Plant physiology, plant biotechnology
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1**: Final written exam: /60 Written exam (tutorial courses): /20 Technical report about practical courses: /20 **Session 2:** Oral presentation: /60 Written exam (tutorial courses): /20 Technical report about practical courses: /20

Course title: Plant Soil Environment

Key words	Plant rhizosphere, nutrition, stress, adaptation, detoxification, soil, societal issues.
Aims	Apprehend an integrated approach of plant-soil interactions for sustainable agriculture, Acquire in-depth knowledge of the properties and vulnerability of agricultural soils.
Content	**Lectures**: - Rhizospheric processes, hydro-mineral nutrition, transport and signaling, - Plant adaptation to soil constraints (water, salinity, nutrients), - Detoxification of trace metals and organic pesticides, - Importance of soil and societal issues: o Impact of changes in organic matter on biogeochemical cycles, o Drought and water erosion, o Pollution and salinization. **Practical courses and Tutorials**: - Illustration of lectures by practical experiments and field trip - Support for the production and presentation of scientific projects related to the subjects covered by the lectures, with the aim of learning to develop a scientific reasoning and to acquired knowledge.
ECTS	**6**
Skills	<u>Knowledge and understanding</u> • Plant-soil exchanges and their impact on plant production, • Physical, chemical and biological processes in soils, • Issues related to soil use in the context of climate change, • Impact of different soil factors on the physiological state of the plant,

	• Analyse and provide solutions to preserve and improve the quality of the agrosystem. <u>Competences and skills</u> <u>For a Judgement and approach</u> For a passing grade the student must: • Be able to assess the impact of agricultural practices on the functioning of the agrosystem, targeting economic and ecological performance objectives. • Be able to integrate soil into agrosystem studies.
Module Coordinator(s)	Patricia Trotel-Aziz
Teaching staff	Aziz Aziz, Cancès Benjamin, Crouzet Jérôme, Lashermes Gwenaëlle, Morvan Xavier, Ponthieu Marie, Trotel-Aziz Patricia
Language of instruction	English
Nb hours of lectures	22h
Nb hours of practical work	10h
Nb hours of tutorials	8h
Nb hours of personal work	40 h (preparation of tutorial, oral presentations, and practical works)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	Recent/significant peer-reviewed scientific publications
Prerequisites	Plant biology and physiology, Sol science.
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam: /40 Written exam (tutorial courses): /20 Oral presentation: /20 Technical report about practical courses: /20 **Session 2:** Final written exam: /70 Technical report about practical courses: /30

Course title: Plant biorefining

Key words	Starch, cellulose, hemicelluloses, pectins, lignins, lipids fibers from plants. Biofuels, biogas, building blocks, biopolymers, biomaterials.
Aims	Acquire the basic knowledge about plant components (biochemistry, properties, biosynthesis) and their further use in biorefining for various applications (bioenergy, building-blocks and materials) Biochemistry and properties of plant components, general knowledge about biorefineries and bioeconomy, the state of biorefineries today : main processes and targeted products
Content	**Lectures** : Introduction to the environmental, societal and innovation challenges of plant biorefining Key plant constituents: starch, cellulose, hemicelluloses, lignins, lipids, proteins 1G, 2G and 3G bioenergies: bioethanol, biodiesel, biogas Synthons and biopolymers (PLA, PE, PET, etc.), biomaterials Zero waste" biorefineries: valorization of agro-industrial co-products **Tutorial classes** : Work in small groups of students on defined topics related to biorefinery ; oral presentation **Practical classes**: 1G and 2G bioethanol production Visit of an agro-industry
ECTS	**6**
Skills	<u>Knowledge and understanding</u> For a passing grade the student must • Understand the concept and challenges of biorefining • Know the composition and properties of plant components • Be able to describe the main extraction processes, the main conversions routes of plant component into bioenergies, biomolecules and biomaterials • Identify and understand the bottlenecks for improving biorefining from different plant components • Know the various application sectors of products from biorefineries <u>Competences and skills</u> For a passing grade the student must • Be able to describe a biorefining strategy from different feedstocks and for various applications • Apply a scientific approach: proposal of a protocol to address a hypothesis, apply the protocol, generate results and interpret them <u>Judgement and approach</u> For a passing grade the student must • Be able to evaluate and describe the complexity of biorefining concept: the bottlenecks from feedstocks to final products • Have an overview of the R&D and innovations in the evolving biorefining concept

Module Coordinator(s)	Caroline Rémond
Teaching staff	Caroline Rémond, Harivony Rakotoarivonina
Language of instruction	English
Nb hours of lectures	20 h
Nb hours of practical work	14 h
Nb hours of tutorials	6 h
Nb hours of personal work	20 h (preparation of tutorial and practical work)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	Articles from the scientific literature
Prerequisites	Biochemistry
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam : /60 Oral presentation (tutorial courses) : /10 Technical report about practical courses: /30 **Session 2:** Final written exam : /80 Oral presentation : /5 Technical report about practical courses: /15

Course title: Molecular Biology of Microorganisms

Key words	Microorganisms (procaryotes and eucaryotes), synthetic biology and microbial engineering, omics, biomolecules and bioproductions
Aims	To acquire basic knowledge in biological systems analyses and synthetic biology to understand tomorrow's challenges in various applications (production of molecules of interest for food/feed environment, biomaterials, energy…)
Content	**Lectures** • Basic in molecular biology • Heterologous expression of proteins for biotechnologies • Metabolic engineering of microorganisms and introduction of synthetic biology for the production of molecules of interest (description of a "chassis", and it uses as cellular factory in industrial applications) • Omic approaches for cellular function studies and biodiversity screening ((meta)genomic, transcriptomic…) **Tutorial class** • Analysis of scientific articles related with lectures and lab classes preparation. • Omic training **Practical class** • Production of a recombinant protein from a genetic modified microorganism • Gene cloning in a plasmid vector • Transformation and selection of a genetic modified bacteria

ECTS	**3**
Skills	Knowledge and understanding For a passing grade the student must understand the concept and challenges of new technologies , biotechnology and their impacts • Know the basis on molecular technology tools and the basis of microbial functioning (structure, genetics, physiology….) (if not acquired in previous years) Competences and skills For a passing grade the student must • Apply a scientific approach: suggest an experimental design to address an issue, apply the protocol, generate results and interpret them Judgement and approach For a passing grade the student must • Be able to evaluate and describe the complexity of molecular biology concept to address an issue
Module Coordinator(s)	Ludovic Besaury
Teaching staff	Ludovic Besaury , Sofiene Abdellaoui, Harivony Rakotoarivonina
Language of instruction	English
Nb hours of lectures	8h
Nb hours of practical work	10h
Nb hours of tutorials	4h
Nb hours of personal work	20h -preparation of tutorials and practical works - scientific literatures - upgrading on basic microbiology, molecular biology and the main cellular functions
Nb hours of other	20h practical reports writing
Length of the internship in weeks	
Bibliography recommended	Articles from the scientific literature : publications directly linked to the lessons and in the field of biotechnology, metabolic engineering and biology of systems
Prerequisites	Basic microbiology, molecular biology, biochemistry
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam : /70 Technical report of practical work: /30 **Session 2**: Final written exam : /70 Technical report of practical work: /30

Course title: Green Chemistry, bio-sourced building-blocks

Key words	Valorization of biomass, green chemistry principles, green (bio)processes, bio-based compounds
Aims	Acquire knowledge on green chemistry (fundamental principles and applications for biorefineries).

	Acquire advanced knowledge on the potentiality of bio-based molecules for and from green chemistry.
Content	- **Lectures** Definition of the 12 Principles of Green Chemistry (green reaction parameters, warning to the importance to analyze a process as a unit, introduction to Ecoscale). - Definition and added value of all factors calculated in green chemistry (E Factor, CE, AE) - Catalysis (homogeneous (metathesis, click, C-H functionalization), heterogeneous (magnetic nanoparticles), micellar (Pr Lipshutz's work), ecocatalysis (Pr Grison's work), Monsanto process) - Eco-processes: flow chemistry, extractions - Clean activation processes (microwaves, ultrasound, mechanochemistry, photoredox catalysis under light irradiation in the visible spectrum) - Unusual media (ionic liquids, DES, perfluorinated solvents, water, supercritical fluids) - Valorization of molecules of interest (cellulose, hemicellulose, lignins, fatty acids...) and access pathways to platform molecules for various fields (biomolecules, biomaterials) **Tutorial classes** Study of scientific publications and oral presentation of the main results of these publications. Work in pairs. **Practical classes** Green reactions through microwaves activation or without solvent
ECTS	**3**
Skills	<u>Knowledge and understanding</u> For a passing grade the student must • Know and understand green chemistry principles • Know and understand major characteristics of catalyses • Be able to identify platform molecules • Know and understand biorefinery processes • Know the main metal-catalysed cross coupling reactions <u>Competences and skills</u> For a passing grade the student must be able to • Compare between oil based chemistry and bio-based chemistry • Analyse the green characters of various processes • Evaluate green chemistry factors • Be able to explain why selective metal-catalysed C-H functionalization is challenging <u>Judgement and approach</u> For a passing grade the student must be able to • Identify limitations of a process in terms of green chemistry and propose greener approaches • Valorize new bio based compounds
Module Coordinator(s)	Sandrine Bouquillon

Teaching staff	Sandrine Bouquillon, Marie Charlotte Belhomme
Language of instruction	English
Nb hours of lectures	12 h
Nb hours of practical work	4 h
Nb hours of tutorials	4 h
Nb hours of personal work	50 h (preparation of practical work and tutorials)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	
Prerequisites	General knowledge of organic and general chemistry. L3 Level.
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam : /50 Oral presentation (tutorial courses) : /30 Technical report about practical courses: /20 **Session 2:** Final written exam : /100

Course title: Enzymes and biorefinery

Key words	Biocatalysis; hydrolysis / esterification / oxido-reduction reactions
Aims	Acquire knowledge on biocatalytic reactions to extract, to fractionate and to convert some plant components
Content	**Lectures** - Economic factors determining the viability of biocatalytic processes, intensification of biocatalytic processes. - Plant biomass fractionation enzymes (cellulases-hemicellulases-ligninases): production routes and applications. - Lipases for the production of biodiesel and esterified derivatives. - Enzymatic glycosylation for glycoside production. - Enzymatic extraction of plant molecules. - Enzymes in the paper industry. **Tutorial classes** - Analysis of articles related to the lectures. - Bibliographical research on a theme chosen by the students in connection with the lectures, synthesis of the bibliographical research in the form of an oral presentation. **<u>Practical courses</u>** Biocatalytic production of biomolecules
ECTS	**3**
Skills	<u>Knowledge and understanding</u> For a passing grade the student must

	- Have up-to-date knowledge of the use of enzymes for plant transformation in industrial processes or processes under development. - Know the various reaction parameters impacting a biocatalytic process biocatalysis principles - Know and understand how using enzymes Competences and skills For a passing grade the student must be able to - Understand the benefits of enzymatic transformation for plant processing and the production of biobased molecules. - Have a global vision of the advantages and disadvantages of an enzymatic process, and be able to propose improvements. Judgement and approach For a passing grade the student must be able to • Know the advantages and disadvantages for biocatalytic processes
Module Coordinator(s)	Harivony Rakotoarivonina
Teaching staff	Harivony Rakotoarivonina, Caroline Rémond
Language of instruction	English
Nb hours of lectures	15 h
Nb hours of practical work	10 h
Nb hours of tutorials	5 h
Nb hours of personal work	25 h (preparation of practical work and tutorials)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	
Prerequisites	General knowledge of biochemistry
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam : /60 Oral exam : /20 Technical report about practical courses: /20 **Session 2:** Final written exam : /60 Oral exam : /40

Course title: Green Line Project – 1st stage

Key words	Biotechnology, bioeconomy, innovation, biomolecules, biorefining, life cycle analysis, white biotechnologies, fractioning, extraction, functional properties, biological activity, chemical intermediates
Aims	• Acquire knowledge on the principal challenges of bioindustries • Acquire knowledge on legislative framework of bioindustries • Conduct scientific literature research and synthesis writing
Content	The valorisation of renewable resources, i.e. biomass in the large sense, is on the base of the bioeconomy. Biomass constitutes a source of molecules, macromolecules and supramolecular assemblies which can be used in numerous applications of virtually every industrial domain, such as food and cosmetics industry, chemical, materials and textile industries, pharmaceuticals and biomedicine. For that, strategies of deconstruction of complex biological tissues need to be employed, using mechanical, chemical, enzymatic (biotechnological) methods. To give some examples, such methods can be employed to fabricate natural antioxidants, pigments, thickening agents, surfactants, lubricants, solvents, materials, composites. White biotechnology or green chemistry can be employed to re-assemble biobased building blocks to substances or assemblies of designed function, such as polymers, fragrances, pharmaceuticals, chemicals. Different real case applications in this domain, such as the development of deconstruction strategies of a given plant for the fabrication of functional polysaccharides, the microbial and/or enzymatic production of platform molecules with valorisation of the co-products, the design of a biorefinery of microalgae, the valorisation of agricultural by-products in the cosmetics industry will be presented by an associated partner during the integration week of Bioceb. A group of 2-3 students willing to work on a given project will be formed. This group will work together during the first semester on the definition of the objectives, structure and boundaries of the project through exchanges with socio-economic bioeconomy actors, industrial actors and literature state of the art. The module consists in: • Introduction lecture on bioindustries • Lectures on demand concerning specific technological needs of a given green line project • Lecture on the legislative framework • Industrial conferences and visits on industrial sites related to the green line project • Interviews with different actors on the subject of the green line project • Tutored literature research and synthesis writing • Writing up of a literature report including state of the art based on academic literature, patents, overview of regulations, technological reports, economic reports
ECTS	**3**
Skills	Knowledge and understanding For a passing grade the student must:

	• Know principal challenges of biobased industries • Know legislative framework of bioindustries • Know structure of principal biomass constituents and their functions • Know principal methods of fractionation of biomass • Know key concepts of the biorefinery, green chemistry and white biotechnology Competences and skills For a passing grade the student must: • Collect information, verify origin and diversity, integrate rules of intellectual property, realize a bibliography • Structure information using an academic formalism Judgement and approach For a passing grade the student must: • Elaborate project presentation and report
Module Coordinator(s)	Sofiene Abdellaoui
Teaching staff	To be defined – depending on the project themes.
Language of instruction	English
Nb hours of lectures	
Nb hours of practical work	
Nb hours of tutorials	
Nb hours of personal work	50
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	
Prerequisites	
Teaching period (when)	All along the first semester
Place of teaching (where)	
Assessment	Written report by groups assessed by the corresponding supervisors