Courses content of the third semester at AgroParisTech

Course title: Bioeconomy

Key words	Bioeconomy – innovation – entrepreneurship – sustainability
Aims	The aim of this module is to give students analytical tools in economics and management of the transition to a bioeconomy. It involves courses in innovation economics and management, entrepreneurship, ecological and environmental economics and sustainability management.
Content	This module entails four courses: - Economics of transition to sustainability - Innovation and entrepreneurship - Environmental accounting and management - Marketing
ECTS	**4**
Skills	Knowledge and understanding For a passing grade the student must • Know the economic dynamics of transition to the bioeconomy • Know stakeholders' strategies in the transition • Know the issues of environmental management and marketing Competences and skills For a passing grade the student must • Be able to formulate an innovation strategy • Be able to understand a transition environment • Be able to formulate a transition strategy Judgement and approach For a passing grade the student must • See courses syllabus
Module Coordinator(s)	Nicolas BEFORT & Stephane LHUILLERY
Teaching staff	To be confirmed
Language of instruction	English
Nb hours of lectures	48
Nb hours of practical work	0
Nb hours of tutorials	0
Nb hours of personal work	20
Nb hours of other	x
Length of the internship in weeks	x

Bibliography recommended	
Prerequisites	none
Teaching period (when)	December 2021
Place of teaching (where)	Agroparistech, Saclay
Assessment	

Course title: Biomolecules, Biomaterials, Bioenergies

Keywords	Renewable carbon, green chemistry, metabolic engineering, plant cell-walls, lignocelluloses, lipids
Aims	The global development of green chemistry stimulates the use of plant biomass for the production of molecules and materials of industrial interest. Biotechnologies constitute one of the major innovation levers in the sector of bio-based industry, both for the optimization of biomass quality and for the design of performant bioconversion tools. In this context, the aims of this module are • To introduce the different declinations of the green chemistry principles (use of renewable carbon and sustainable chemical synthesis) • To show how they can be applied to the transformation of plant biomass by combining chemistry with different biotechnological routes (plant-, microbial- and animal-based biotechs) • To provide practical examples of green chemistry approach and stimulate their critical analysis
Content	This module comprises the following courses: - presentation and critical analysis of the green chemistry principles applied to the conversion of plant biomass into molecules, materials and energy, taking into account regulation and toxicology (6 h), - functionality and exploitation of natural molecular assemblies such as lipid bodies and plant cell-wall (6 h), - complementarity between plant biotechnologies and industrial biotechnologies (white biotechs) illustrated through examples relative to chemical intermediates, polymers, and ingredients for cosmetics (6 h), - state of the art of insect biorefinery (3 h) - practical work at lab scale in groups (21 h) combining fractionation, chemical conversion, biocatalysis and characterization of intermediate bioproducts (comparison of different raw materials and conversion strategies), - preparation and presentation of an oral communication on the practical work (6 h)
ECTS	**4 ECTS**
Skills	**Knowledge and understanding** For a passing grade, the student must: • Know the green chemistry principles and the main regulations associated to green chemistry principles in Europe, • Understand the complementarity between biotechnologies and chemistry for the production of targeted biomolecules and functionalities,

	• Know and understand the concept of rational deconstruction of biomass **Competences and skills** For a passing grade, the student must: • Be able to implement the green chemistry principle for the design and critical analysis of biomass conversion routes • Be able to exploit the structural diversity and variability of plant biomass to produce functional bioproducts • Be able to present and justify a strategy for the valorisation of a given biomass.
Complementary skills	Team work and communication, design of experimental set-up
Module Coordinators	Stéphanie Baumberger, Jean-Luc Cacas
Teaching staff	Stéphanie Baumberger, Jean-Luc Cacas, Florian Pion, Sandra Domenek, Valérie Camel, IJPB researchers, members of companies involved in biobased industries (insect biorefinery, cosmetics, chemical industry).
Language of instruction	English
Nb hours of lectures	21h
Nb hours of practical work	21h
Nb hours of tutorials	
Nb hours of personal work	3h
Nb hours of other	3h for oral communication in group
Length of the internship in weeks	Not applicable
Bibliography recommended	Anastas, PT, Warner JC (1998). Green chemistry: theory and practice. New York, Oxford University Press, By permission of Oxford University Press. Scherrman MC, Augé J (2016). Chimie verte – Concepts et applications. Paris, EDP Sciences CNRS Edition, Savoirs actuels.
Prerequisites	Background in biotechnologies and/or green chemistry
Teaching period (when)	January
Place of teaching (where)	Versailles / Paris Saclay Palaiseau
Assessment	Oral evaluation of the student groups by a jury composed of teachers and IJPB researchers. Groups of students will present their practical work and propose a critical analysis of the experimental strategy implemented, with respect to green chemistry principles.

Course title: Cell factory design

Module's title	**Cell factory design**
Keywords	synthetic biology, metabolic engineering, systems biology
Aims	Synthetic Biology (Metabolic engineering, strain design optimisation, etc.) is a discipline 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.
Content	In this course, we will seek to practically explore this "pipeline". Students will be expected to perform an in silico optimization of a bacterial cell factory for production of a given target metabolite. The model predictions (genes to inactivate or overexpress) will guide the genetic manipulation that will be performed in wet lab. These will include clean knock-outs and expression modulation via synthetic promoters. Finally, the success of the engineering approach will be validated by quantifying the produced metabolite in batch cultures. • Practical works in metabolic engineering in silico • Wet lab project (gene cloning, gene KO, modifying gene expression)
ECTS	**6 ECTS**
Skills	**Knowledge and understanding / Competences and skills** 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 • Choose the most suitable approach to conceive a bacterial cell factory for a given target metabolite
Complementary skills	• Use of the English language for the analysis of articles. • Ability of writing scientific reports in English.
Module Coordinators	Matthieu Jules (AgroParisTech, Micalis), Vincent Fromion (INRA, MaIAGE)
Envisaged teaching staff	Matthieu Jules (AgroParisTech, Micalis), Vincent Fromion (INRA, MaIAGE), Anne Goelzer (INRA, MaIAGE), Laurent Tournier (INRA, MaIAGE), Vincent Sauveplane (AgroParisTech, Micalis)
Langage of instruction	English
Nb hours of lectures	22h
Nb hours of practical work	8h (project work)
Nb hours of tutorials	18h
Nb hours of personal work	0
Nb hours of other	0
Length of the internship in weeks	Not applicable
Bibliography recommended	Old and new scientific articles explaining the basic and scientific advances in Systems and Synthetic Biology. Two general references on Systems Biology and metabolic engineering: • Systems Biology [Textbook], E. Klipp et al, Wiley-Blackwell, 2011. • Metabolic engineering in the post genomic era, ed. B.N. Kholodenko, H.V. Westerhoff, Taylor & Francis, 2004.
Prerequisites	Courses in systems biology and synthetic biology recommended
Teaching period (when)	October (all week days)
Place of teaching (where)	Univ Paris Saclay and Evry

Assessment	Students will be evaluated based on their involvement (activity) in practical courses. In addition, they will write a technical report on their project, and will be evaluated on that as well.

Course title: Genetic manipulation of plant resources

Keywords	molecular biology, transgenesis, experimental research, plant physiology, genetic resources, protein and lipid biochemistry
Aims	Acquiring basic knowledge of transgenesis in plants and getting into the process of phenoytpe interpretation. The proposed example deals with lipid metabolism. Therefore, it is assumed that students will also learn a bit about this theoretical aspect, but also about basics of lipid extraction, purification and dosage.
Content	This teaching unit is about performing transient expression of transgene in plants and understanding the ins and outs of one such technology. It is based on (i) molecular biology manipulation (cloning the gene of interest and transferring the construct into agrobacteria), (ii) tobacco plant transformation using agrobacteria and (iii) phenotype analyses. Practical courses are majority during the teaching process (around 30h out of the 45h-lasting module). Students attending this unit will learn a scientific approach that can be useful for their future career either in the academic research world or in a broader biotechnological (R&D) context.
ECTS	**6 ECTS**
Skills	**Knowledge and understanding / Competences and skills** Basically, it is expected that each pair of student chooses a gene-of-interest (GOI) in the provided unpublished list from my lab and goes through the whole experimental process, that is to say: cloning the GOI by gateway technology, checking for positive clone, transforming and growing Agrobacterium tumefaciens bacteria, using Agrobacterium for transforming tobacco leaves, checking for gene expression by confocal microscopy, checking for protein expression by western blotting method, extracting lipids and quantifying fatty acid levels by GC-MS. This intensive program can be adjusted depending on the student number, but will anyway help them designing experimental plan and acquiring autonomy at the bench.
Complementary skills	Team work and communication
Module Coordinators	Jean-Luc Cacas
Envisaged teaching staff	Jean-Luc Cacas, Lionel Gissot, Sabine D'Andrea
Langage of instruction	English
Nb hours of lectures	15h
Nb hours of practical work	30h
Nb hours of tutorials	0
Nb hours of personal work	0
Nb hours of other	0
Length of the internship in weeks	Not applicable
Bibliography recommended	-
Prerequisites	-
Teaching period (when)	October (Tuesday and Wednesday)
Place of teaching (where)	Versailles

Assessment	Students are evaluated at the end of the teaching unit by means of oral presentations. Each pair of student gives a talk on its own results/interpretations, putting forward the case for potential biotechnological applications.

Course title: Extraction and separation strategies in bio-industries: evolutions and innovations

Key words	Eco-design of separation processes, Innovative technologies, green solvents, green extraction
Aims	Separation processes are key operations in bio-industries, either for raw materials treatments or for downstream operations (concentration, extraction, cracking, purification). The recovery of molecules of interest from biomass and from biotechnological transformations is a major issue, either from economic and environmental point of view. Many evolutions and innovations are currently proposed in this area, in order to reduce environmental impact and increase global performances. This module will aim at describing the main principles and scopes of separation and extraction processes, for different technological maturity stages, from emergent to mature technologies. The focus will be placed on sustainability criteria of these processes, to raise students' awareness of eco-design challenges to tackle in this field.
Content	Lectures on eco-design, innovative separation technologies, eco-extraction…, performed by researchers in the field and professional stakeholders. For mature processes, focus will be placed on evolutions dealing with process control for a better adaptation of technology to resources specificity (e.g. microalgae biomass), or to obtain new functionalities. For more recent innovations, the challenges to tackle in term of eco-design and reduction of environmental impacts, through solvent use reduction and energy saving, will be presented. Small group or individual Projects, as a tutored work on a case study of an innovative separation challenge
ECTS	**5**
Skills	Knowledge and understanding For a passing grade the student must • Know the main principles of downstream processes • Know the eco-design principles • Know the green extraction principles • Understand the role of some innovations involved in downstream processes Competences and skills For a passing grade the student must • Review sets of papers to provide a short synthesis on the treated topic regarding an innovative separation process

	• Include in the review the eco-design approach Judgement and approach For a passing grade the student must • Critically evaluate the sustainability of studied processes • Propose changes to improve the sustainability
Module Coordinator(s)	Violaine Athès and Marwen Moussa, AgroParisTech
Teaching staff	INRA : Caroline Penicaud University of Avignon : Sylvie Fabiano Tixier University of Nantes : Luc Marchal, Estelle Morin Coualier
Language of instruction	English
Nb hours of lectures	15
Nb hours of tutorials / project	12
Nb hours of personal work	3
Nb hours of other	6 (oral communication)
Bibliography recommended	
Prerequisites	
Teaching period (when)	Beginning of january – Beginning of february
Place of teaching (where)	Paris (2021) and Palaiseau (afterwards)
Assessment	Collective (maximum of 3 students) work (10 pages report) and oral presentation (30 minutes) on a project dealing with extraction strategies and innovations.

Course title: Specialized metabolites in biotechnologies

Module's title	**Specialized metabolites in biotechnologies**
Keywords	Plants, fungi, bacteria, secondary metabolism, bioactive molecules, biomimicry
Aims	• Exploring specialized metabolite diversity (multi-omics), • Understanding primary and secondary metabolism, • Manipulating secondary metabolism (environment and genetics), • Purifying and characterizing metabolites, • And screening of novel molecules and evaluation of their biological activity .
Content	We propose to explore and compare specialized metabolite diversity in bacteria, fungi and plants. For that purpose, students will be taught by experts in the field (through a conference cycle): (i) the basics of primary and specialized metabolism and its regulation, (ii) methodologies dedicated to explore, identify, purify, characterize and screen metabolites and determine their biological activity, and (iii) manipulation of metabolic pathways via genetic-dependent and -independent strategies. This will provide the necessary knowledge for students to conceive and develop, with the help of teachers, an innovative project that deals with a specific metabolite or specific family of metabolites. In this project evaluated by the pedagogical team, biotechnological applications/procedures will be

	emphasized. To illustrate lectures/projects, “omics” facilities or companies will also be visited.
ECTS	**6 ECTS**
Skills	**Knowledge and understanding** For a passing grade, the student must: • Know and understand the concept of primary and secondary metabolism, • Know and understand the concept of structure/function relationships, • Know one specialized metabolism pathway, • Know and understand basics of omics approaches, • Understand basics of functional genetics, • Understand analytical methods dedicated to purification and characterization of metabolites, • And know examples of specific metabolite discovery in an innovation context. **Competences and skills** For a passing grade, the student must: • Distinguish among primary and specialized metabolites, • Be able to conceive and develop a screening strategy for identifying metabolites with specific biological activity, • And be able to identify metabolites that could have biotechnological potential.
Complementary skills	Team work and communication, building of project
Module Coordinators	Jean-Luc Cacas, Florian Pion, Loïc Rajjou
Teaching staff	Jean-Luc Cacas, Florian Pion, Loïc Rajjou, Séverine Layec, Bertrand Gakière, Adnane Boualem, Erwan Poupon, Muriel Viaud, Loïc Lepiniec, Xavier Cachet, Marc Litaudon, external teachers
Language of instruction	English
Nb hours of lectures	24h
Nb hours of practical work	0
Nb hours of tutorials	21h
Nb hours of personal work	0
Nb hours of other	3h for visiting fluxomic facilities (IPS2) or companies (like Alkion)
Length of the internship in weeks	Not applicable
Bibliography recommended	-
Prerequisites	Interest in natural substances and their applications
Teaching period (when)	November
Place of teaching (where)	Versailles / Paris Saclay Palaiseau
Assessment	Oral evaluation of student groups by a jury composed of teachers and other students. Groups of students will present their work in an innovation contest.