

Unit title	Code	Module title	Details	Hours number	ECTS Credits
BIOREF L1					
Plant Biomass Production and valorisation	L1A	Land plants : Ligno-celluloses, starch and proteins	Structure (composition & organisation) of plant cell walls constituting lignocellulosic biomass - Biological sources of variability in biomass composition - Introduction to protocols and techniques used in the compositional analysis of lignocellulosic biomass. The structure and metabolism of starch in plants, as well as basic methods for the analysis of starch samples including starch assaying methods, protein and phosphate contents determination, amylose/amylopectin ratio and amylopectin structure analysis, etc). Biomass production and recycling : Forage plant proteins :Recovery of plant proteins is a major concept in green biorefinery: are addressed in this lecture the plant sources, the recoverable protein fractions and protein processing, especially for feed and food production.	20	5
	L1B	Aquatic Biomass	Key challenges in microalgal and macroalgal biomass production: physiological requirements, cultivation and optimization.	11	
	L1C	Type of biorefineries, line products	The different types and concepts of biorefineries are presented. Typical operations and material flows, economic, logistical, energy, social, ethical, etc. aspects are discussed to prepare students for the specialized study of each one, with an integrated view of the whole.	4	
BIOREF L2					
Biomass pretreatment and thermal treatment	L2A	Cellulosic biomass pretreatment : Hydrolyse, fermentation, chemical treatment	Introduction to the chemical and biotechnological methods employed for the pretreatment and the enzymatic hydrolysis of the lignocellulosic biomass. In addition, the fermentation of sugars to chemicals, using bio-ethanol as an example, is presented.	6	5
	L2B	Lignin pretreatment : radical and chemical pretreatments	Teaching on lignin: structure, composition, process to recover lignin, valorization of non modified and modified lignin to fine chemicals, polymers, fuels...	7	
	L2C	Algae fractionation : to protein, sugars, lipids, fine chemicals			
	L2D	Gasification of biomass – Syngas production and valorisation			
	L2E	Biogas from waste, residual biomass, environmental issues	Anaerobic digestion is a process of degradation of organic matter that generates a biogas (methane and carbon dioxide) and a digestate (organic residue). Aspects such as degradation mechanism, reactors and issues of the process are reviewed, as well as the aspects of purification, valorisation, environmental regulations and safety of the formed products.	6	

BIOREF L3					
Energy from biomass	L3A	H2 Production	Hydrogen : first presenting some generalities, history, natural occurrence, and the production of hydrogen today. Then, the major part of the course concerns the production of hydrogen from bio-resources, including current researches.	4	5
	L3B	Biocarburant production	While the electrification of transportation vehicles is currently progressing, the use of biofuels still has a large potential of reduction of greenhouse gases emissions. Through an introduction to combustion science and the importance of chain-branched kinetic mechanisms in combustion phenomena, the basics of fuel-engine adequacy will be exposed, for past and future engine technologies. The course provides a comprehensive, up-to-date and multidisciplinary review of major industrial thermochemical processes for biofuels manufacturing. An emphasis is given to the reactors and processes for manufacturing of biofuels of second and third generation. Numerous aspects relevant to the technology, economic, environmental and social benefits of biofuels and reduced emissions of greenhouse gases are addressed in this course	22	
	L3C	Non-conventional carburant			
BIOREF L4					
Chemicals from biomass	L4A	Homogeneous catalysis for biomass conversion	Basis of organometallic chemistry and homogeneous catalysis, with a combined overview of academic and industrial achievements and applications. Exemplification in the field of biomass upgrading is provided for major classes of reactions and substrates Homogeneous catalytic carbonylation and etherification reactions in the field of biomass upgrading. Detailed mechanistic aspects for a better understanding of the concepts of homogeneous catalysis. Overview of biosourced polymers, rather focused on synthesis / chemistry. High throughput characterization of catalysts using X-ray diffraction (XRD), X-ray Fluorescence (XRF), Raman and InfraRed spectrometers and Inductively coupled plasma- optical emission spectrometry (ICP-OES).	24	10
	L4B	Heterogeneous catalysis for biomass conversion	Basis of catalysis - chromatography basis- characterization techniques (BET/XPS/XRD/NMR/...) Catalytic biomass valorisation (lignocellulosic and oleaginous)- currents and future process applied in biorefineries Introduction to the catalytic valorisation of carbohydrates. The first part covers the chemistry of sugars including structure, stereochemistry and chemical activity of sugars. During the second part of the course the introduction to the catalytic valorisation of different carbohydrates by heterogeneous catalysis is given.	22	
	L4C	Biotechnology for biomass conversion	Basis of microbial physiology, fermentation processes and methods employed to analyze, design and modify metabolic pathways to improve a microbial biocatalyst in order to understand the basic engineering concepts underlying the biocatalytic conversion of raw materials to products including fuels and chemicals. Theoretical and applied concepts on the use of enzymes in homogeneous or heterogeneous catalysis and the implication of enzymatic catalysis in the concept of hybrid catalysis (combination with chemical catalysis)	21	
BIOREF L5					
Language	L5	English	The English course with Bioref aims at mastering Academic English as used in universities and scientific laboratories, with a focus on scientific audio and written documents plus class discussion on extra topics related to science. Internet sources such as Ted Talks are used to trigger discussion about the impact of technological innovations on today's world. A workbook of activities and exercises is used.	48	5