**Learning Outcomes**

**I semester**

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| 1) CRYSTAL ENGINEERING | At the end of the course the student has acquired knowledge to design, prepare and characterize crystalline molecular materials and coordination networks and to study crystal polymorphs and co-crystals. |
| 2) MOLECULAR AND SUPRAMOLECULAR PHOTOCHEMISTRY | At the end of the course the student has acquired knowledge to analyze photoinduced intra- and intermolecular processes and to design photoactive molecular and supramolecular systems with applications for energy conversion, smart materials and luminescent biosensors. |
| 3) FUNCTIONAL POLYMERIC MATERIALS | At the end of the course the student has acquired knowledge on structure-property relationships of polymeric materials designed to perform specific functions. The student will be able to identify the elements of the macromolecular chemical structure that influence the requested functionality, as well as the structural and morphological parameters that influence the final properties of the material. |
| 4A) MOLECULAR ELECTROCHEMISTRY | At the end of the course the student has acquired the theoretical and experimental basis for the comprehension and investigation of the physical-chemical processes associated to electron transfer processes, either heterogeneous or homogeneous and intramolecular. |
| 4B) PROPERTIES AND PROCESSES IN THE CONDENSED PHASE | At the end of the course the student has acquired knowledge necessary to bridge molecular, surface and solid state properties and to investigate also dynamical aspects of matter. |

**II semester - Energy**

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| 5) MOLECULAR NANOTECHNOLOGY | At the end of the course the student has acquired the basic concepts and the main strategies for the bottom-up construction of functional nanostructures, starting from molecules and using the paradigms of supramolecular chemistry: molecular devices and machines, dendrimers, nanoparticles, self-assembled monolayers and thin films. |
| 6) PHOTOACTIVE MATERIALS AND TECHNIQUES FOR ENERGY CONVERSION | At the end of the course, the student has acquired knowledge of the advanced methodologies and applications in the fields of lighting (LED and OLED), solar energy conversion and storage, photocatalysis and on the working principles and use of the simplest photochemical techniques both in steady-state and time-resolved regime. |
| 7) MOLECULAR MATERIALS: PROPERTIES AND MODELLING | At the end of the course, the student has acquired knowledge of the main computational techniques useful for the study of molecules and aggregates in their ground and excited states and for the study of static and dynamic properties of molecular materials. |
| 8) MATERIALS ORGANIC CHEMISTRY WITH LABORATORY | At the end of the course the student has acquired knowledges towards the design and synthesis of conjugated organic compounds and laboratory experience of multi-step synthesis and analytical/spectroscopic characterization of conjugated organic molecular materials. |

**II semester – Health**

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| 5) BIOMIMETIC MATERIALS | At the end of the course the student has acquired knowledge to design, develop and characterize inorganic and organic-inorganic materials with tailored technological properties, according to the biomimetic principles, such as synthesis in confined reaction spaces, templated synthesis, morphosynthesis, crystal tectonics. |
| 6) COMPUTATIONAL METHODOLOGY AND STATISTICAL ANALYSIS | At the end of the course the student has acquired theoretical and computational approaches to study the properties of health related materials, including complex molecular architectures and the basic concepts of probability distributions, and statistical tools used in treating experimental data and tackle biological intrinsic variability. |
| 7) PROCESSES OF CELL MATTER | At the end of the course the student has acquired knowledge on i) the physico-chemical principles governing physiological and pathological cellular processes and driving biological macromolecule activities; ii) cellular processes that can be targeted for specific drug delivery and tissue and organ engineering. |
| 8) BIOCONJUGATION AND RADICAL CHEMISTRY | At the end of the course the student has acquired knowledge of the general strategies of synthesis, purification and characterization of bioconjugates and radical reactions that lead to the oxidation of organic and biological materials, the main mechanisms of antioxidant action and the relationship between structure and antioxidant activity. |

**III semester – Energy**

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| 9A) LASERS | At the end of the course the student has acquired the basic principles of laser operation, knowledge of their optical properties and the chemical applications of the main commercially available laser sources. |
| 9B) ELECTROCHEMICAL SYSTEMS FOR ENERGY STORAGE AND CONVERSION | At the end of the course the student has acquired basic and technological knowledge of the most advanced materials for energy storage and/or conversion systems (lithium batteries, supercapacitors and fuel cells) and main electrochemical techniques for testing and characterization of materials and devices. |

**III semester – Health**

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| 9) NANOMEDICINE AND LIGHT-RESPONSIVE SOFT MATERIALS | At the end of the course the student has acquired the knowledge for the design of contrast agents for the most common imaging techniques and of possible drug delivery systems, with a critical approach to nanomedicine, the knowledge of kinetic and thermodynamic stability of colloidal systems and stimuli-responsive materials, as well as of the main photochemical techniques used to investigate them. |

**Elective courses – Energy**

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| MATERIALS SPECTROSCOPY | At the end of the course, the student has acquired the fundamentals of materials spectroscopy, quantum theory of solids, as well as spectroscopic techniques based on absorption/emission, light scattering, and magnetic properties. |
| POLYMERS FOR ENERGY AND ADVANCED APPLICATIONS | At the end of the course the student has acquired the knowledge for the comprehension of the structure-property correlations in polymeric materials to achieve stimuli responsiveness and the knowledge of the most important classes of polymeric materials used for energy storage, energy conversion and for advanced applications. |
| STATISTICAL TREATMENT OF EXPERIMENTAL DATA | At the end of the course the student has acquired the basic concepts of probability distributions, statistical tools used in treating experimental data, fluctuation analysis and classification of noise sources. |
| ENVIRONMENTAL PHOTOCHEMISTRY AND PHOTOPROTECTION | At the end of the course the student has acquired the basic principles and conventional techniques used for environment-related photoprocesses, such as air purification and water treatment/disinfection, as well as photoprotection of materials and living organisms. |
| ADVANCED ORGANIC SYNTHESIS FOR FUNCTIONAL MATERIALS | At the end of the course the student has acquired the theoretical basis necessary to design and undertake the synthesis of principal molecular building blocks used in optoelectronics, the covalent fucntionalization of carbon nanoforms, sustainable C-H activation protocols, visible-light photo- and carbocatalysis. |
| ORGANIC ELECTRONICS: MATERIALS AND APPLICATIONS | At the of the course the student has acquired the basic knowledge for studying the electronic and photonic processes involved in molecular solids, as well as some basics on organic materials and organic electronic devices. |
| STRUCTURAL DETERMINATION OF CRYSTALLINE SOLIDS | At the end of the course the student has acquired a basic knowledge of structure determination and refinement from powder and single crystal diffraction data. |

**Elective courses – Health**

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| DIAGNOSTIC AND MICROFABRICATION TECHNIQUES FOR HEALTHCARE | At the end of the course the student has acquired knowledge on: i) the advanced techniques for the investigation of cell/material interfaces; ii) the signal transduction strategies, which are based on physico-chemical and electrochemical principles, employed in the clinical diagnosis; iii) nano-microfabrication tools and surface modification routes used in healthcare sensors and medical devices. |
| APPLIED BIOMATERIALS | At the end of the course the student has acquired basic knowledge of bone and articular tissue, biomaterials commonly used for the bone tissue regeneration and for bone implants. |

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| POLYMERIC MATERIALS FOR LIFE SCIENCE | At the end of the course the student has acquired a deep knowledge of the properties of the main polymeric materials that are used in the biomedical and pharmaceutical field, as well as the principles of biocompatibility and biodegradability of the polymeric materials used for regenerative medicine and drug release applications. |
| BIOMIMETIC SUPRAMOLECULAR CHEMISTRY | At the end of the course the student has acquired knowledge of the properties and transformations of the main classes of supramolecular systems, the biomimetic approach to their design and application, the main techniques used for their characterization. |
| ASTROBIOLOGY | At the end of the course the student has acquired a deep knowledge of the chemistry occurring in space in connection with the formation of prebiotic molecules, as well as the principles the techniques for the discovery of molecules in space and the theories at the basis of the origin of life on Earth. |
| PHOTOBIOPHYSICS AND PHOTOBIOLOGY | At the end of the course the student has acquired an interdisciplinary basis for the study of photobiological processes at the molecular level, with special emphasis on photosynthesis and photoreception. |
| ELECTRONIC AND OPTICAL MICROSCOPY | At the end of the course the student has acquired knowledge of the most common electronic and optical microscopies used for the characterisation of materials and biomolecules and the analysis of the acquired images. |