
NEW!
In 2022-23 two curricula
Energy and Health

Master Degree **Photochemistry and Molecular Materials**

Course timetable – 1st year – I semester

- **Crystal Engineering** 6 ECTS
- **Molecular and supramolecular photochemistry** 8 ECTS
- **Functional polymeric materials** 6 ECTS

- **Physical Chemistry: chemical and electrochemical properties**
  - Molecular electrochemistry 6 ECTS
  - Properties and processes in the condensed phase 6 ECTS

Energy – II semester

- **Molecular Nanotechnology** 6 ECTS
- **Photoactive materials for energy conversion** 10 ECTS
- **Molecular materials: properties and modelling** 6 ECTS
- **Materials organic chemistry with laboratory** 6 ECTS

Health – II semester

- **Biomimetic Materials** 6 ECTS
- **Computational methodology and statistical analysis** 8 ECTS
- **Processes of cell matter** 6 ECTS
- **Bioconjugation and radical chemistry** 10 ECTS

International Master Degree

Photochemistry and Molecular Materials

Course timetable – 2nd year – I semester

Energy

- **Applied Physical Chemistry**

- Lasers	6 ECTS
- Electrochemical systems for energy storage and conversion	6 ECTS

Health

- **Nanomedicine and light-responsive materials** 10 ECTS

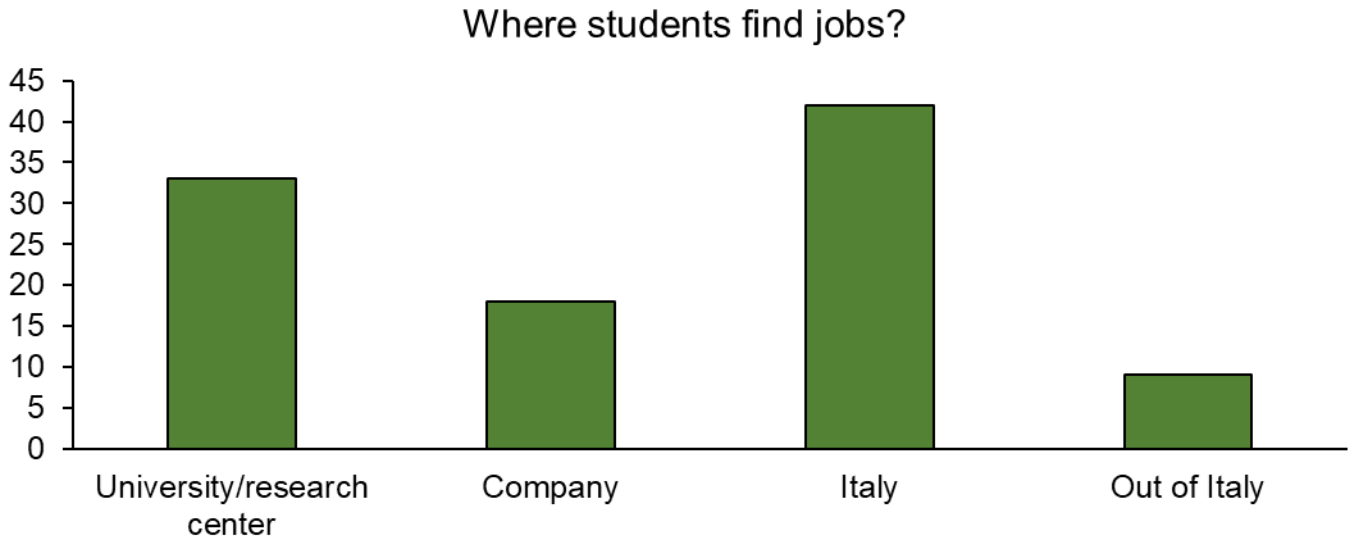
Elective or free choice activities

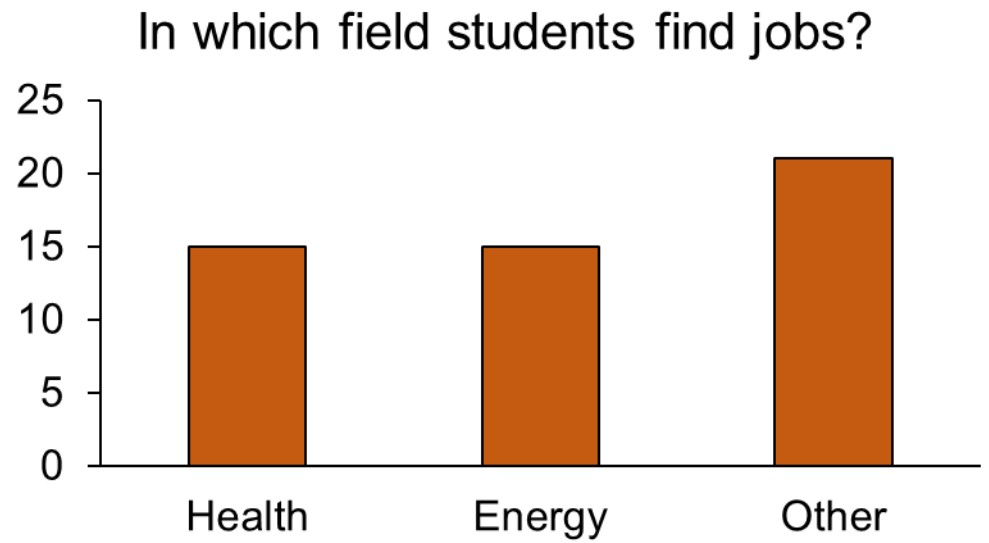
- Materials spectroscopy
- Polymers for energy and advanced applications
- Statistical treatment of experimental data
- Environmental photochemistry and photoprotection
- Advanced organic synthesis for functional materials
- Organic electronics: materials and applications
- Structural determination of crystalline solids
- Diagnostic and microfabrication techniques for healthcare
- Applied biomaterials
- Polymeric materials for life science
- Biomimetic supramolecular chemistry
- Astrobiology
- Photobiophysics and photobiology
- Electronic and optical microscopy

Internship

Survey

over about 50 students graduated in Photochemistry and Molecular Materials (2018-2021)





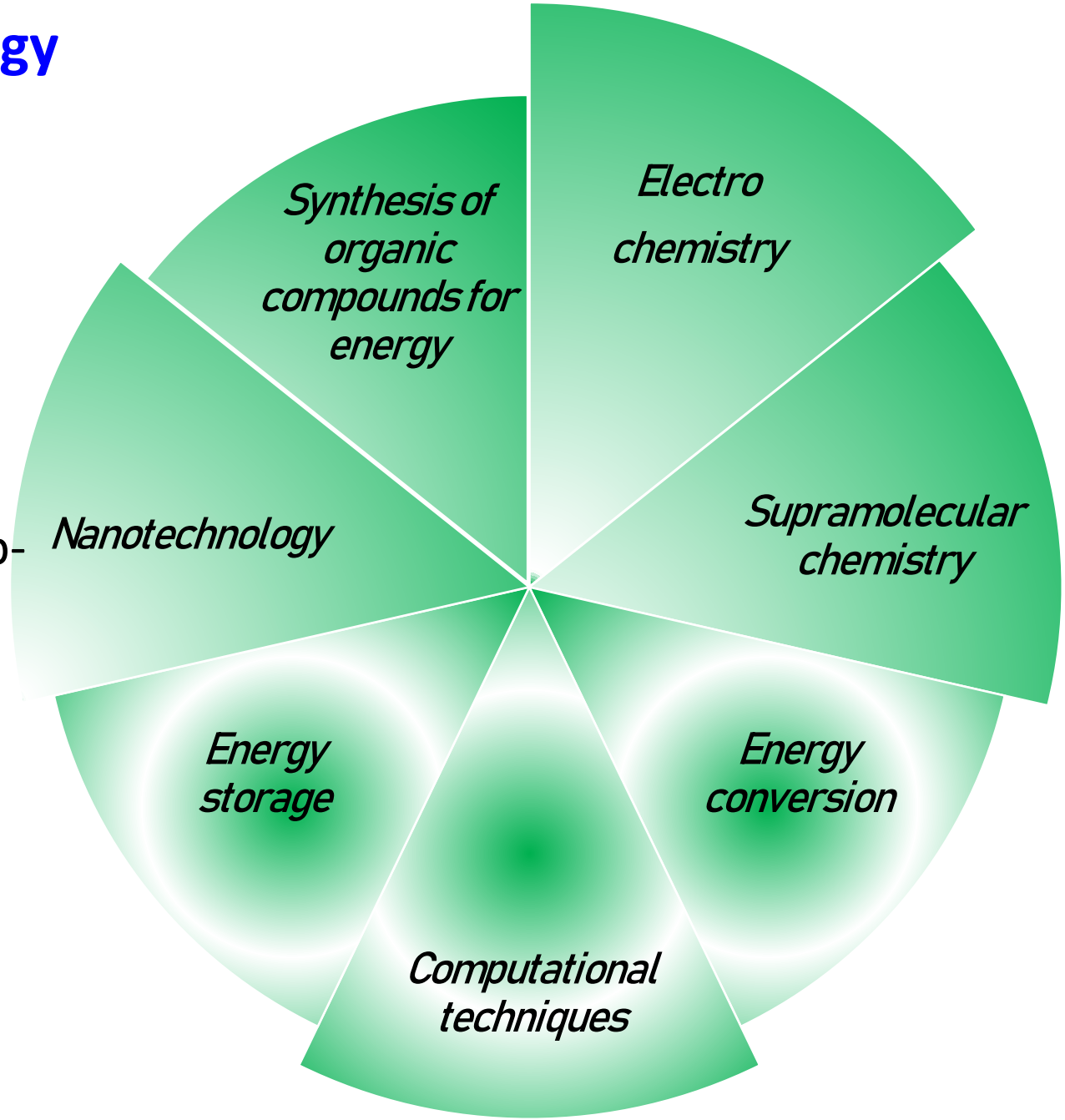
- The interviewed students are all Italian
- Most of our students are interested in continuing their academic careers
- Part of the students are abroad (with a PhD position)

- Most of our students find job in sectors related either to health or energy
- The number of students working in health sector is the same of that working in the energy sector

Curriculum energy

Chemistry and photochemistry for energy

- Create new materials for clean and efficient energy conversion and storage.
- Materials designed by a bottom-up and a top-down approach
- Combine the theory, computer simulations, synthetic approaches and testing



1st year

Energy – II semester

➢ **Molecular Nanotechnology**	6 ECTS
➢ **Photoactive materials for energy conversion**	10 ECTS
➢ **Molecular materials: properties and modelling**	6 ECTS
➢ **Materials organic chemistry with laboratory**	6 ECTS

2nd year

Energy

➢ **Applied Physical Chemistry**	
- Lasers	6 ECTS
- Electrochemical systems for energy storage and conversion	6 ECTS

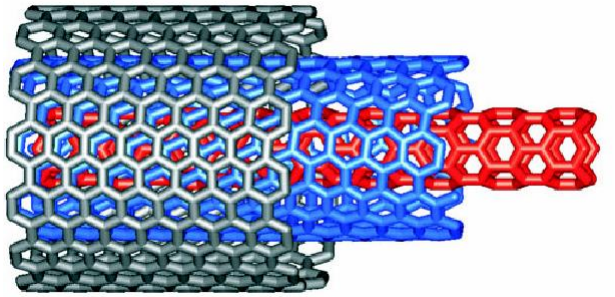
- Materials spectroscopy
- Polymers for energy and advanced applications
- Statistical treatment of experimental data
- Environmental photochemistry and photoprotection
- Advanced organic synthesis for functional materials
- Organic electronics: materials and applications
- Structural determination of crystalline solids

MOLECULAR NANOTECHNOLOGY

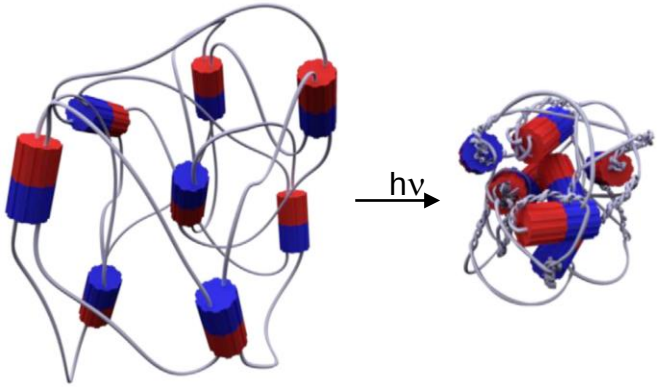
Prof. Serena Silvi, 1st year 2nd semester

As the world's energy demand continues to grow, the development of **more efficient and sustainable technologies** for generating and storing energy is becoming increasingly important. **Nanotechnology** has shown promise to have a significant impact on the energy industry, as it is being used in several applications to improve the environment and to produce more efficient and cost-effective energy.

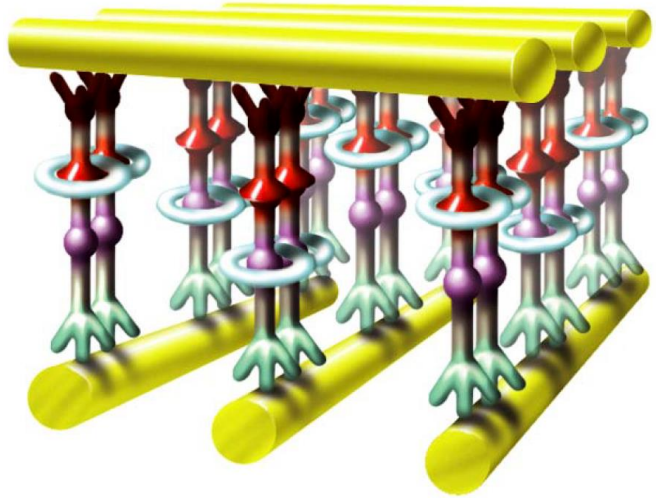
The course on Molecular Nanotechnology provides the strategies for the bottom-up construction and characterization of functional nanostructures, starting from molecules and using the paradigms of **supramolecular chemistry**: molecular devices and machines, dendrimers, nanoparticles, nanomaterials, self-assembled monolayers and thin films.



Carbon nanotubes



Photoinduced macroscopic contraction of a gel containing molecular rotary motors



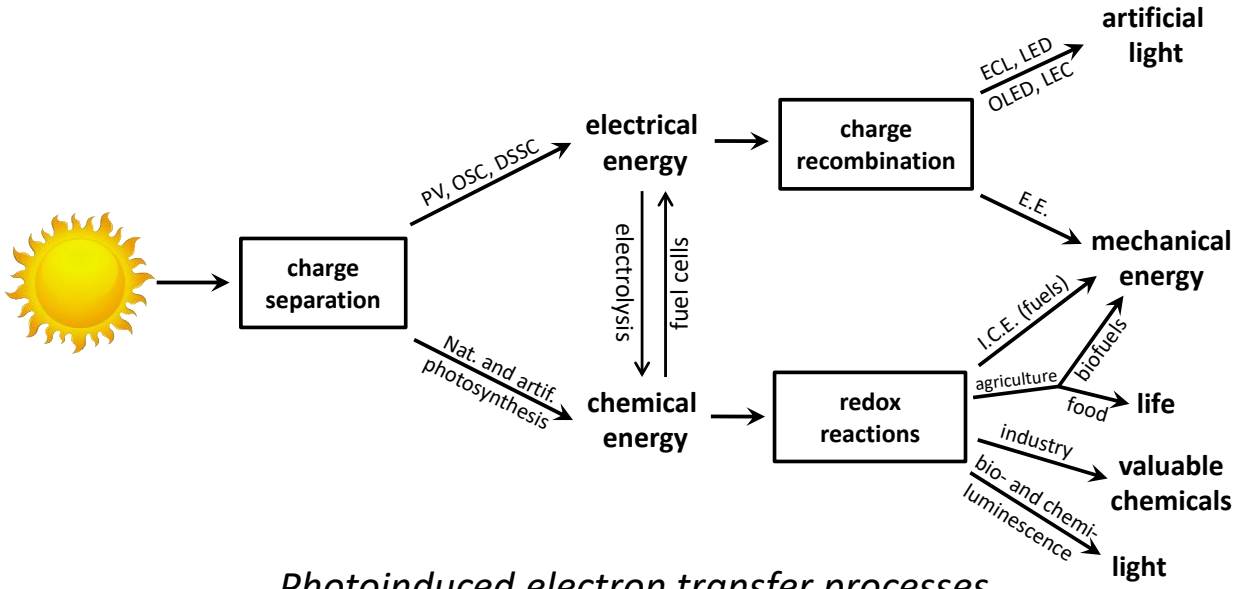
Assembling nanocircuits from the bottom up

PHOTOACTIVE MATERIALS FOR ENERGY CONVERSION

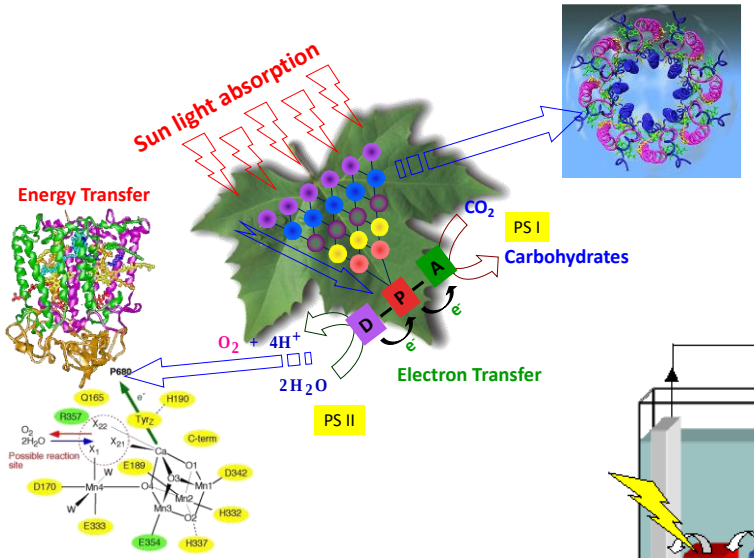
Prof. Giacomo Bergamini, 1st year - 2nd semester

In the current quickly developing world, we are concerned with the increasing consumption of natural resources, climate change, energy crisis, and degradation of the environment. We must evaluate the carbon-free primary energy resources available and take the right direction towards sustainability as it is strongly interconnected to economy, ecology and society.

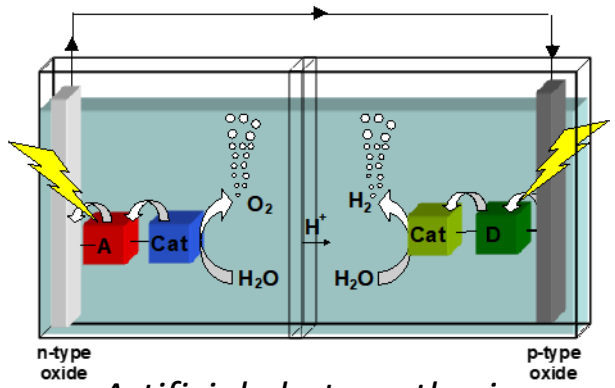
The course provides account on supramolecular photochemistry and analysis of some photoactive materials (quantum dots, metal nanoparticles, organic nanostructures, organic frameworks, organic and inorganic semiconductors, heterostructures, hybrid materials): **from design to application**.



Photoinduced electron transfer processes



Natural photosynthesis



Artificial photosynthesis

PHOTOCHEMISTRY LABORATORY

Prof. Montalti Marco (module 1), Dr. Marco Villa (module 2) 1st year - 2nd semester

Photochemical methods and photophysical instrumentation are **powerful tools** that find application in more and more fields, like LED/OLED manufacturing, photocatalysis reaction, UV based curing and pollutants degradation. These tools and techniques are used from simple characterization of products to advanced research activity.
The course on Photochemistry Laboratory provides the knowledge of the common **steady-state and time-resolved techniques and instrumentations** and is split in two parts:

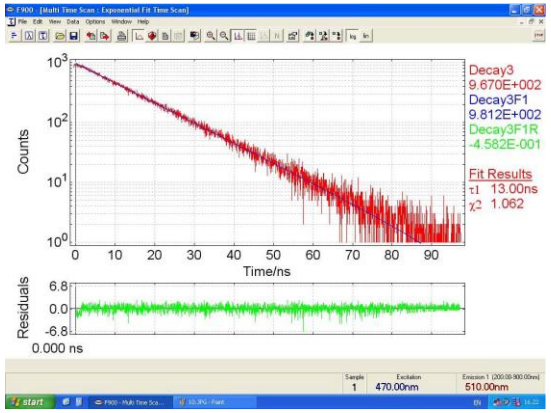
PART 1: PHOTOCHEMICAL TECHNIQUES

- Fast survey on electronic absorption spectroscopy
- Emission spectroscopy, with emission and excitation spectra and lifetime
- Emission quenching and sensititation
- Transient absorption spectroscopy (technics and instrumentation).

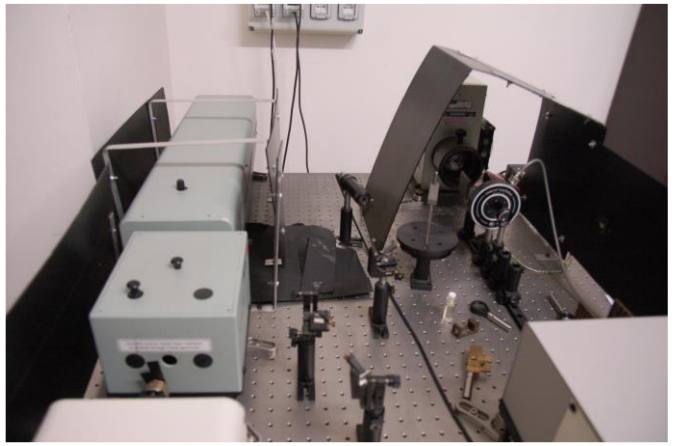
PART 2: LABORATORY OF PHOTOCHEMISTRY

Photophysical characterization of compounds:

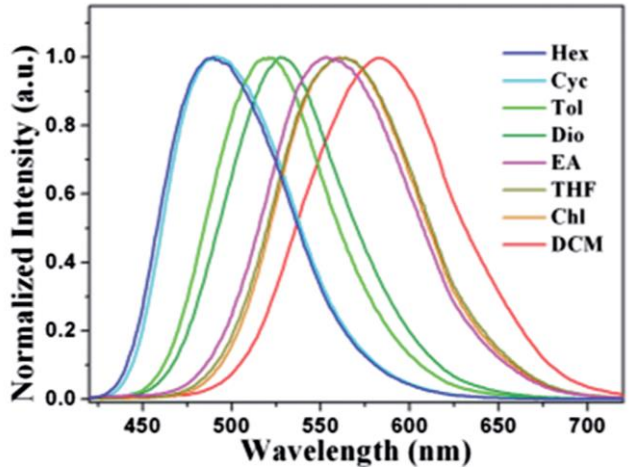
- Determination of absorption and emission spectra,
- Photochemical reactivity and actinometers
- Emission quantum yields and lifetimes



Fluorescence lifetime of a dye



Transient absorption spectroscopy setup



Emission spectra of a solvatochromic dye

MATERIALS ORGANIC CHEMISTRY WITH LABORATORY

Prof. Marco Bandini & Prof. Andrea Gualandi, 1st year 2nd semester

Organic electronics (small molecules and polymers) are expected to impact several areas of modern nanotechnologies (i.e. light emitting diodes, solar cells, ionizing radiation detectors, memories, and chemical/biological sensors ect…) in the near future.

The development of ***S*imple, *S*elective and *S*ustainable ("The 3-*S* role") synthetic technologies** for realization of functonial π-organic compounds is getting exponential credit both on small- and large-scale productions.

The course of **Materials Organic Chemistry with Laboratory** will provide an overview of the main class of organic compounds with optoelectronic properties. Their design and synthesis will be discussed during the frontal lectures and in laboratory the student will face the multi-step synthesis of organic compound used in optoelectronic devices.

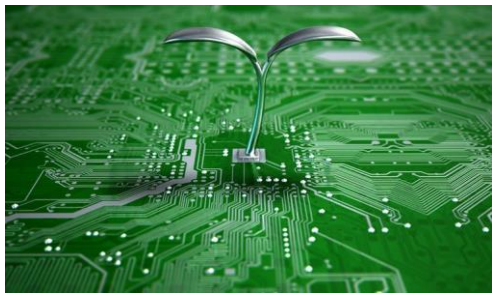
Recent Nobel Prize Organic reactions

2005 – Metathesis reactions

2010 – Pd-catalyzed cross couplings

2022 - Click chemistry

Sustainable synthesis of π-functional compounds for organic electronics



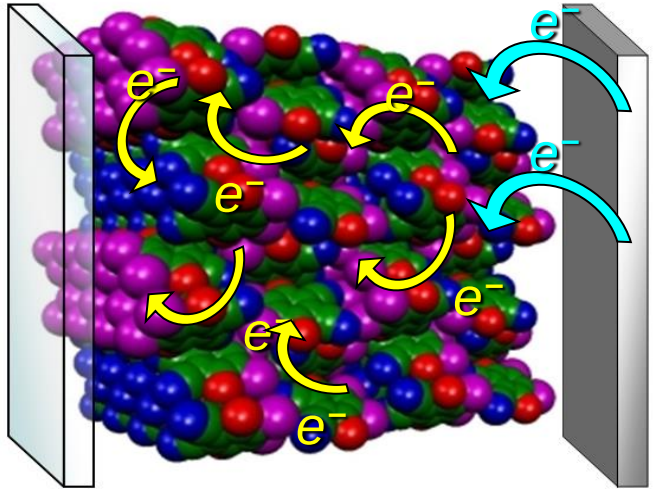
Advanced Synthetic Laboratory Training

Molecular Materials: Properties and Modelling

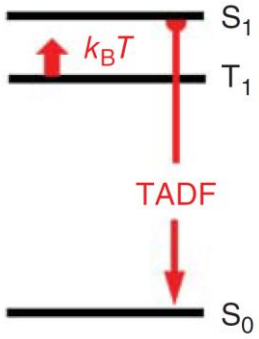
Prof. Fabrizia Negri, 1st year, 2nd semester

New and innovative applications in the field of electronics are rapidly emerging. Organic semiconductors have recently gathered lots of attention due to their unique properties. Conjugated molecules and polymers are an emerging class of materials for large-area solid-state energy conversion and storage applications.
In this context, computational models are required to rationalize materials properties and to guide experimental efforts toward the design of more efficient materials.

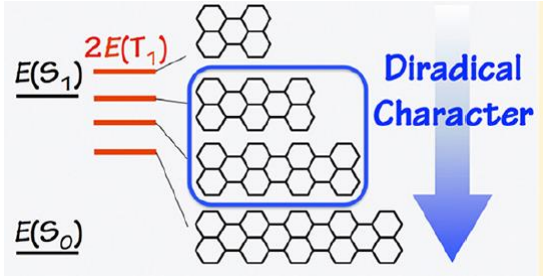
This course offers an overview of computational approaches suitable to simulate molecular properties and processes in molecular materials by combining the fundamental understanding of quantum chemical and classical molecular dynamics approaches, an appreciation of their limitations and the ability to embrace new and emergent technologies.
Examples of processes and properties that will be discussed in the context of computational approaches are shown below.



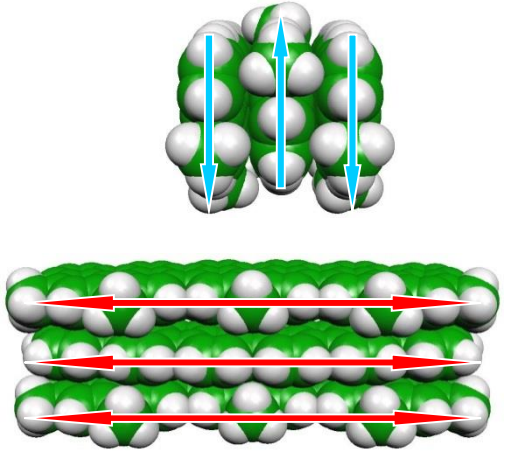
Charge and energy transport in organic semiconductors



Thermally activated delayed fluorescence



Singlet fission

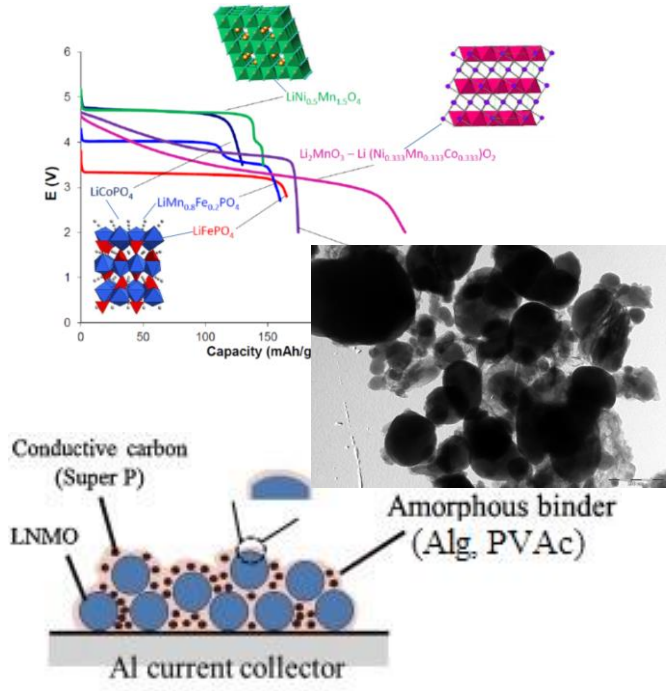


Optoelectronic properties of Molecular aggregates

Electrochemical Systems for Energy Storage and Conversion

Prof. Catia Arbizzani, 2nd year 1st semester

Present **state-of-the-art technologies** of rechargeable lithium-based batteries, supercapacitors and fuell cells for portable, transport and stationary applications.
Basic aspects of **electrochemistry** and of energy storage and conversion systems.
Safety, Ecodesign, Life Cycle Assessment (LCA) and Recycling.
Electrochemical techniques for characterization of materials and devices.
Lab experiences will be performed on the characterization of materials, electrodes and devices.



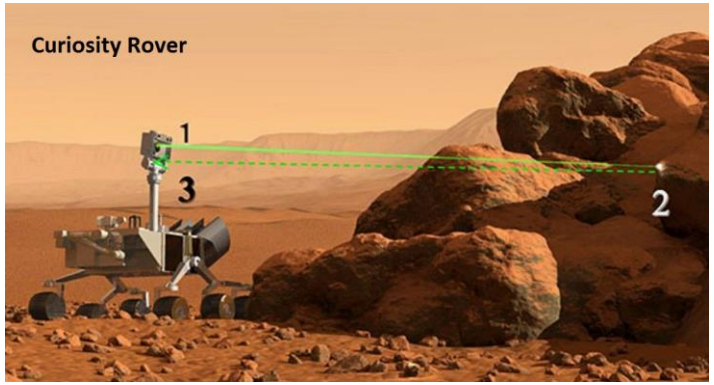
LASERS

Prof. Assimo Maris, 2nd year 1st semester

Laser is recognized as one of the top technological achievements of 20th century and there are few areas in science and technology that are not influenced by it. It plays an important role in, medicine, industry, and entertainment has resulted in fiber-optic communication, CDs, CD-ROMs, and DVDs. Without lasers there would be no supermarket bar code readers, certain life-saving cancer treatments, or precise navigation techniques for commercial aircraft. Laser is acronym of Light Amplification by Stimulated Emission of Radiation. Laser is a source of light but it is different from other light sources. Laser makes a high intensity and extremely directional beam which has a narrow frequency range, incredible coherence and ultrashort pulses.

The course provides the **basic principles of Laser operation, the optical properties which characterize the Laser radiation and various applications of the main Laser sources which are commercially available**.

Laser for material processing



Laser breakdown spectroscopy on Mars

Laser for nuclear fusion

Elective or free choice activities

- Materials spectroscopy (**Prof. Assimo Maris**)

  fundamentals of materials spectroscopy, quantum theory of solids, spectroscopic techniques based on absorption/emission, light scattering, and magnetic properties.

- Polymers for energy and advanced applications (**Prof. Chiara Gualandi**)

  Stimuli-responsive polymers, polymers for energy storage, energy conversion and for advanced applications.

- Advanced organic synthesis for functional materials (**Prof. Marco Bandini**)

  Synthesis of principal molecular building blocks used in optoelectronics, the covalent functionalization of carbon nanoforms, sustainable C-H activation protocols, visible-light photo- and carbocatalysis.

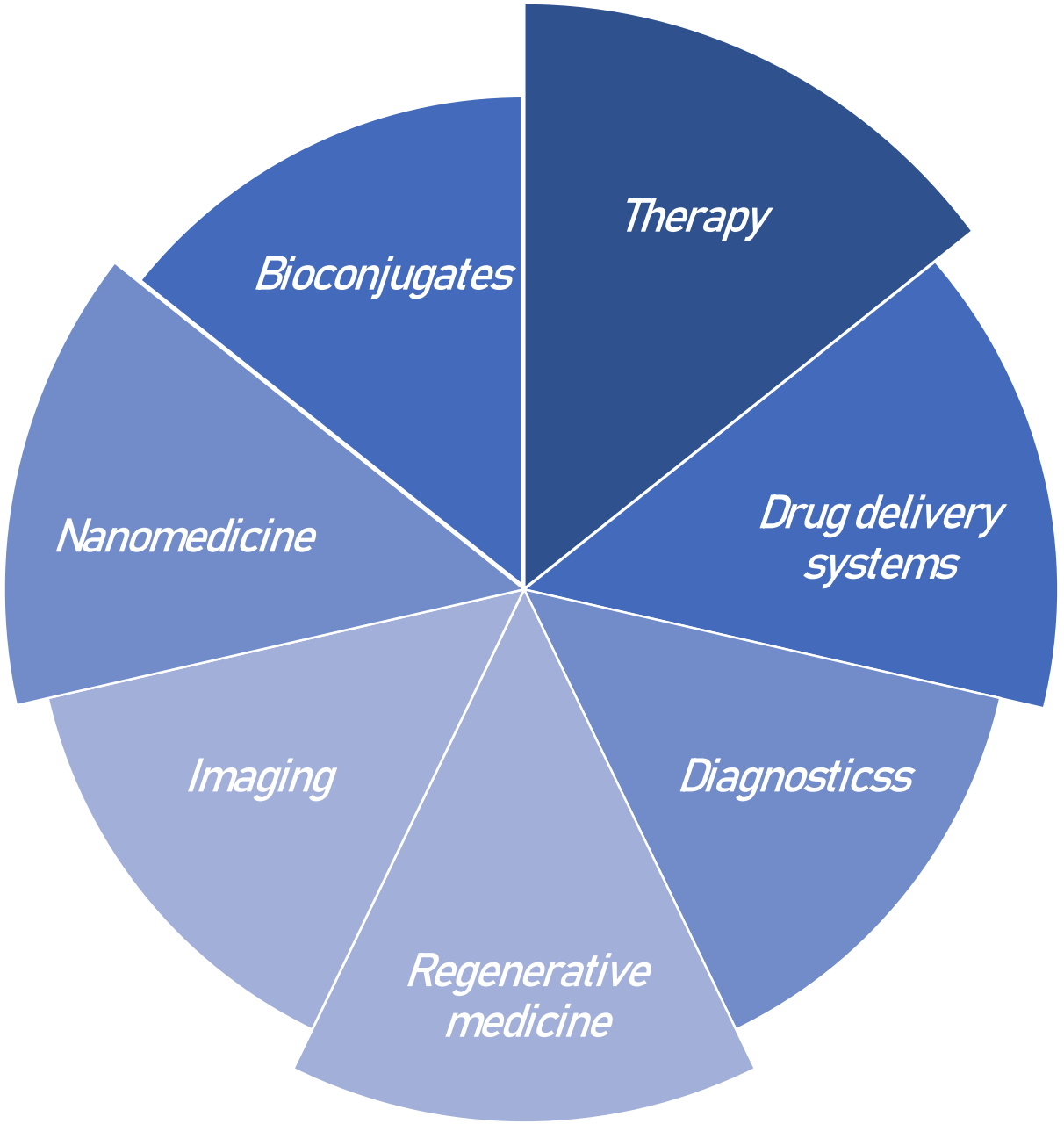
- Organic electronics: materials and applications (**Prof. Nadia Camaioni**)

  Electronic and photonic processes involved in molecular solids, some basics on organic materials and organic electronic devices

Curriculum health

Chemistry and photochemistry for health

- Theranostics (therapy, imaging and functional imaging)
- New sensing transduction methods and point-of-care (POC) devices
- New anticancer and antimicrobic therapies
- Sustainable synthesis and characterization of materials for health and regenerative medicine
- Multiscale modelling of health-related materials
- Prevention of diseases and improvement of human health



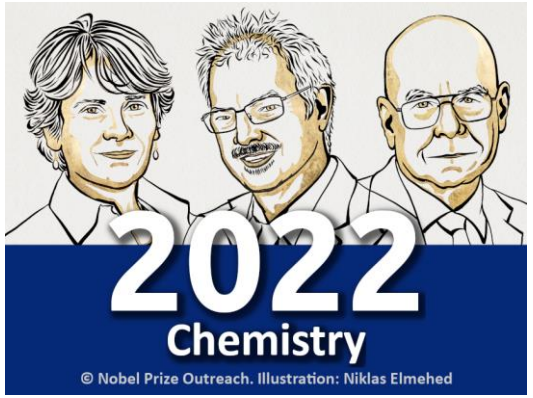
BIOCONJUGATE TECHNIQUES

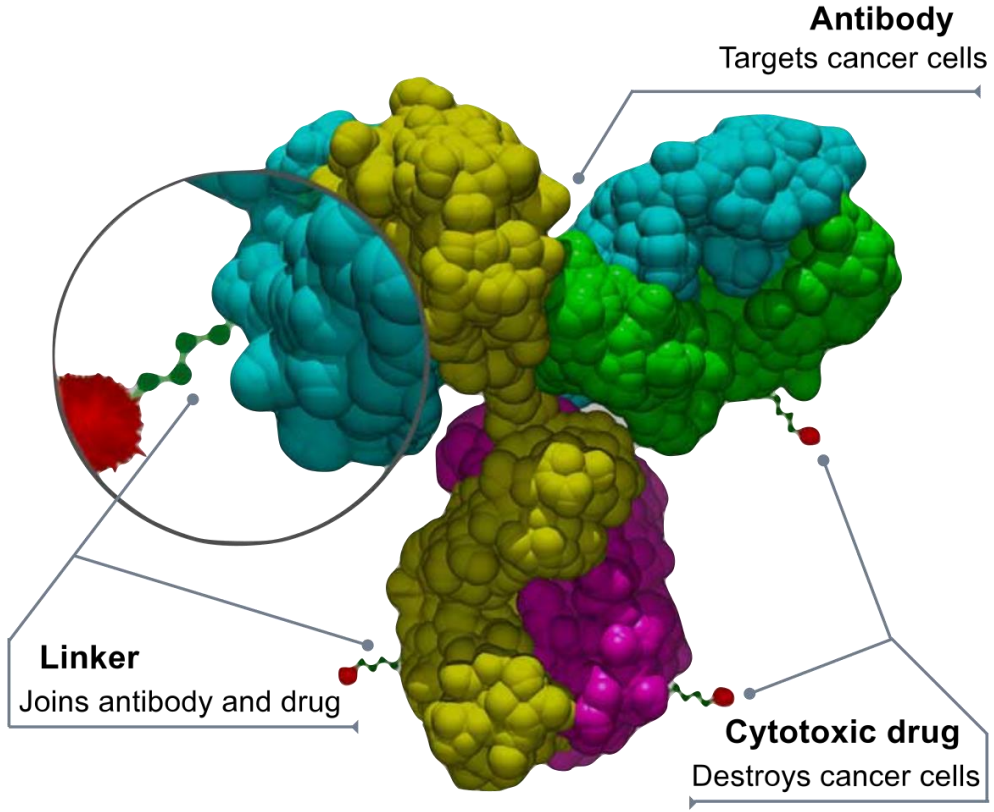
Prof. Matteo Calvaresi, 1st year 2nd semester

General strategies of synthesis, purification and characterization of bioconjugates and nanobioconjugates.
Bioconjugation of proteins, polysaccharides and polynucleotides.
Bioconjugation of micro- and nano-particles and surfaces

3CFU → Lectures
- The fundamental principles of bioconjugation including the major types of bioconjugates and their components,
- The best strategies and designs for making an optimal bioconjugate,
- The major application areas of how bioconjugates are being used today

2CFU→ Lab Activities
Execution of experiments in the lab during which the students will perform the synthesis purification and characterization of bioconjugates/nanobioconjugates.





PHISICAL ORGANIC CHEMISTRY
Prof. Riccardo Amorati, 1st year 2nd semester

5CFU→ Lectures

1) Structure and properties of free radicals

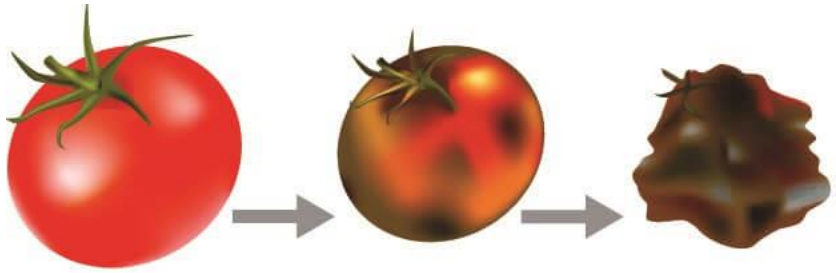
2) Reaction of auto-oxidation

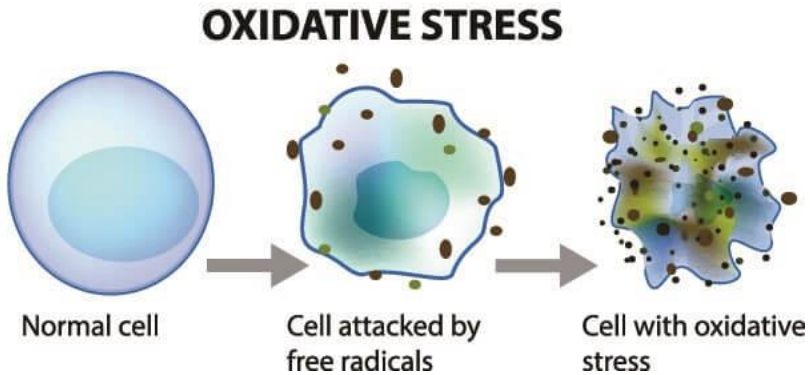
3) Antioxidants

4) Measure the antioxidant activity

5) EPR spectroscopy

6) Oxidative stress in biological systems





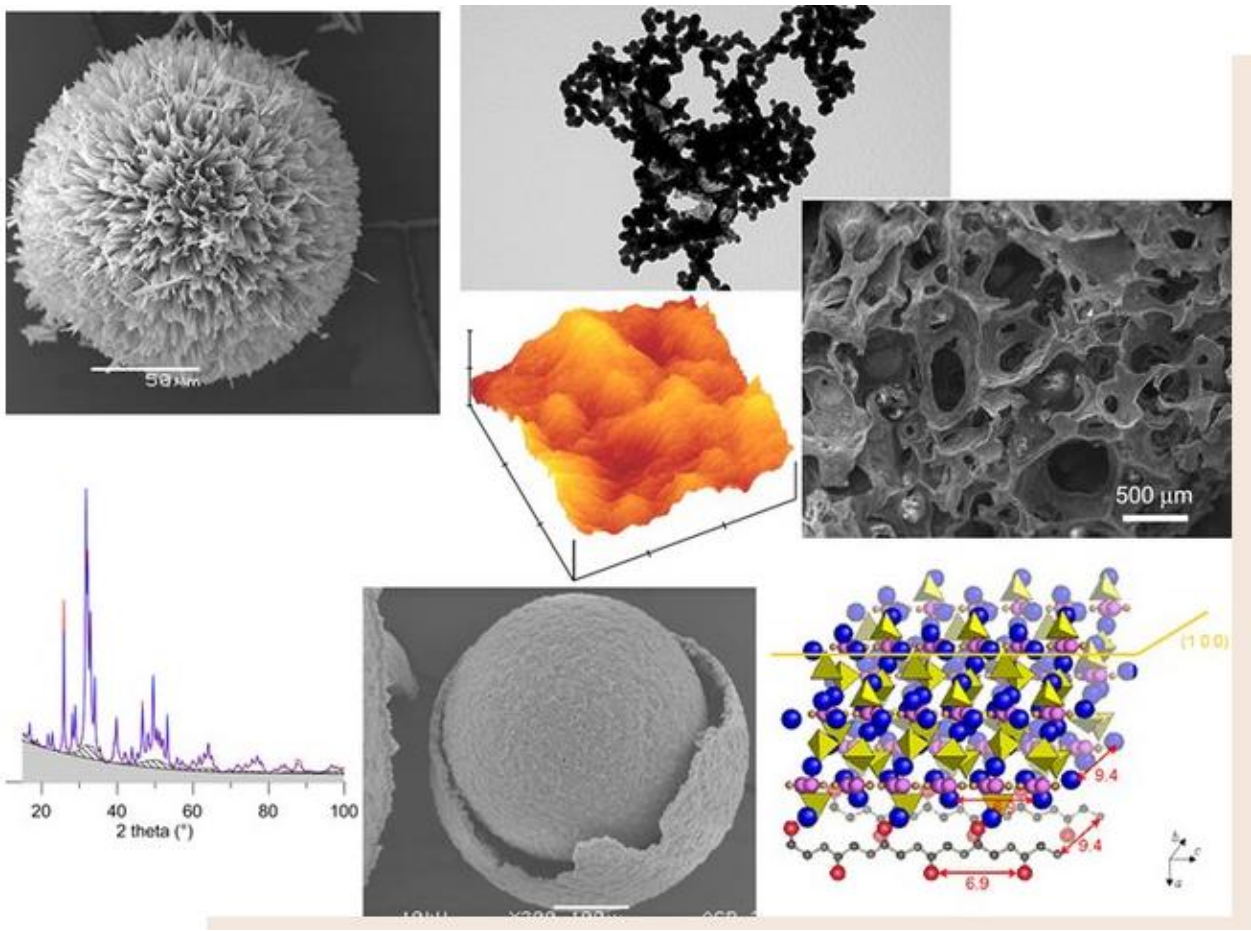
BIOMIMETIC MATERIALS
Prof. Elisa Boanini, 1° year 2° semester

The course *Biomimetic materials* will present methods and strategies to design, develop and characterize inorganic and organic-inorganic materials with tailored technological properties, according to the biomimetic principles.

The course will deal with topics such as:

- Biomineralization processes
- Synthesis in confined reaction spaces
- Templated synthesis
- Morphosynthesis
- Crystal tectonics
- Composite biomaterials

6CFU→ Lectures



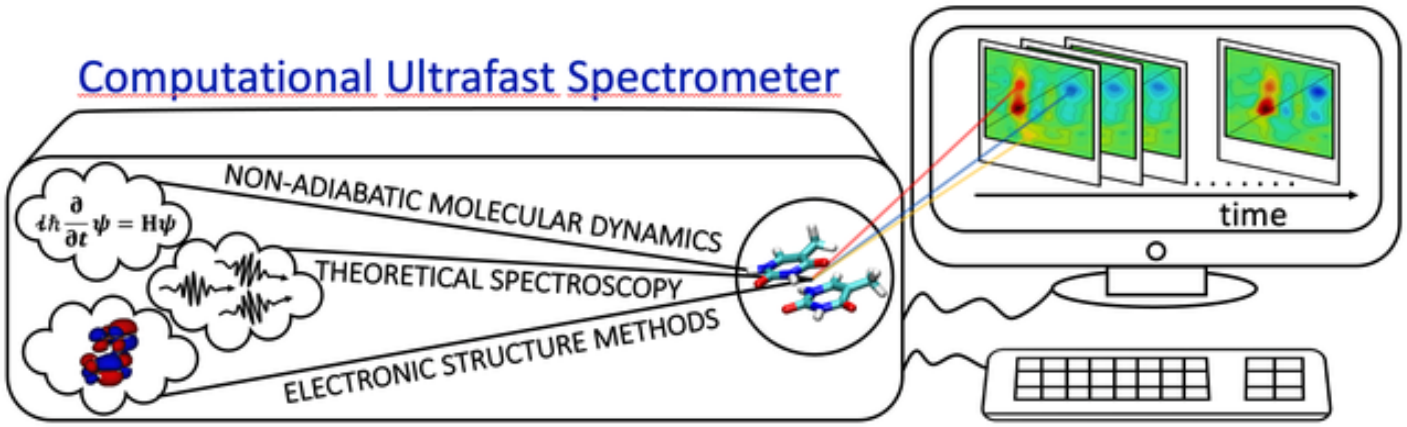
COMPUTATIONAL METHODOLOGY
Prof. Marco Garavelli, 1st year 2nd semester

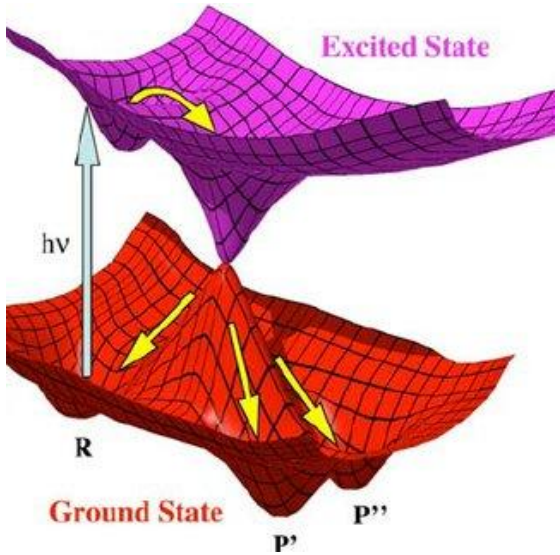
5CFU→ Lectures and laboratory exercises

Theoretical and computational approaches to study the properties of health related materials

Use and the application of qualitative theoretical models to the understanding, modeling and prediction of chemical reactivity in (Photo)Chemistry.

The fundamental tools of Computational (Photo)Chemistry are also provided and applied during the laboratory exercises, to solve actual problems of structure and reactivity in Photochemistry, Photobiology and Material Chemistry



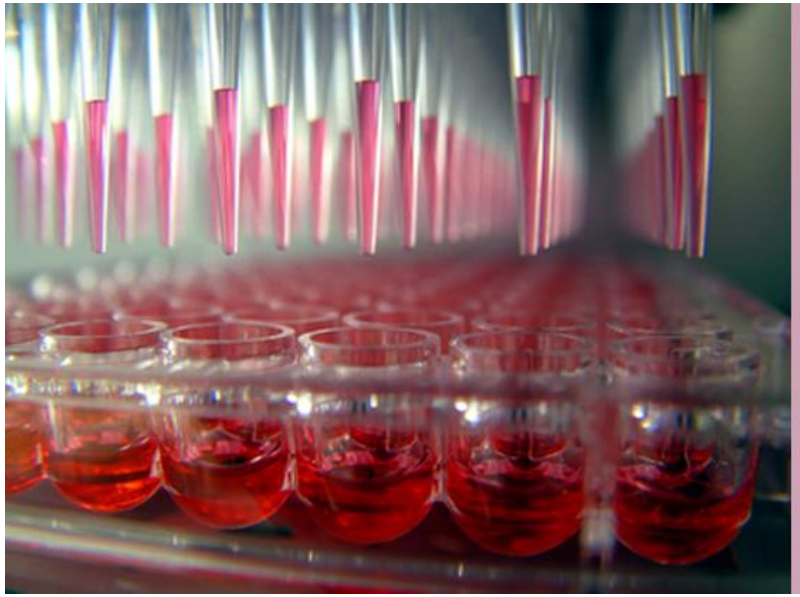


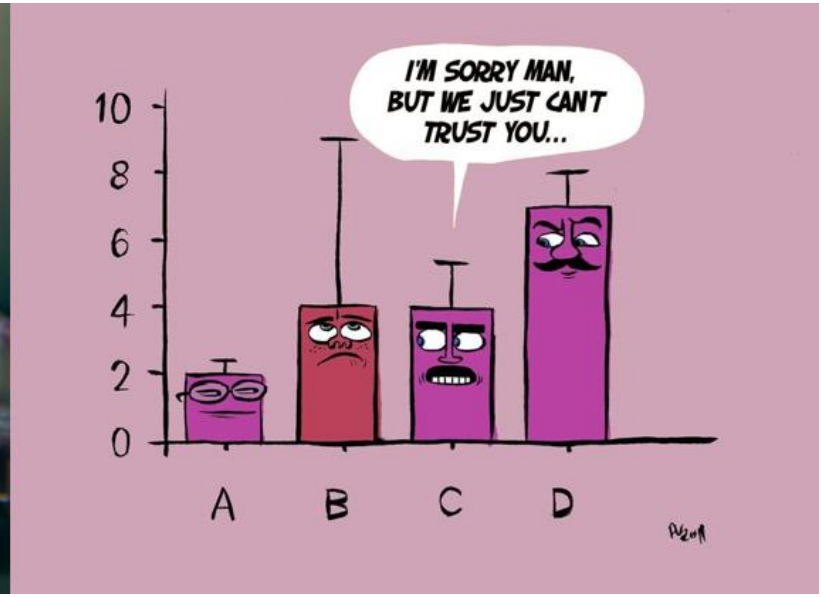
STATISTICAL ANALYSIS

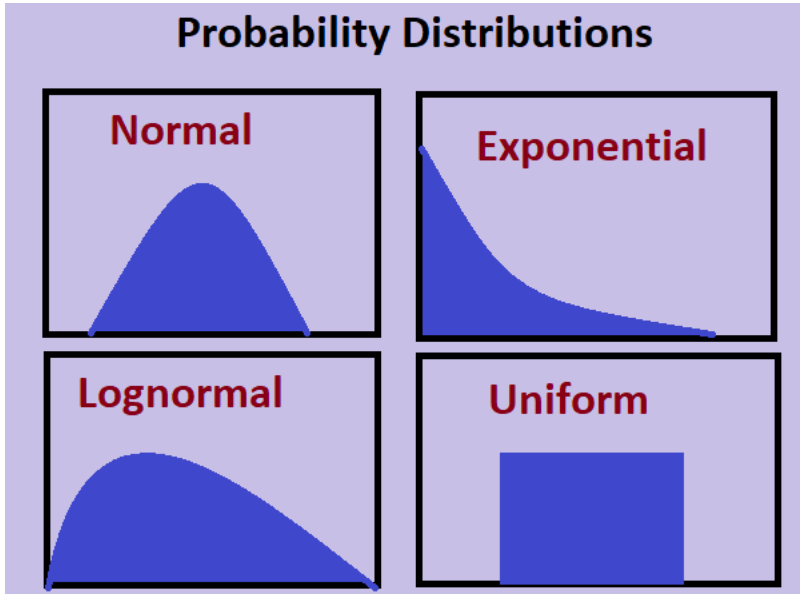
Prof. Evangelos Bakalis, 1st year 2nd semester

3CFU→ Lessons and exercises in the classroom

Basic concepts of probability distributions, and statistical tools used in treating experimental data and tackle biological intrinsic variability.





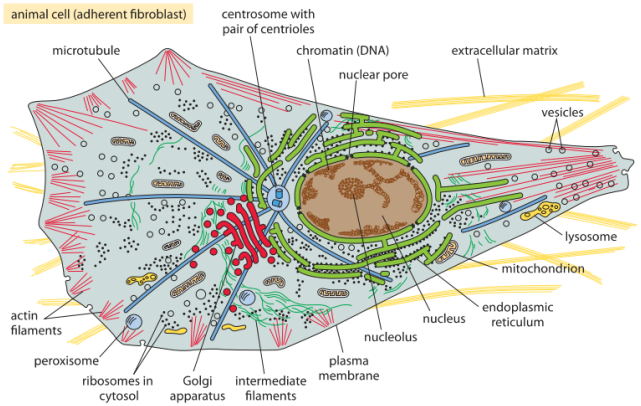


PROCESSES OF CELL MATTER

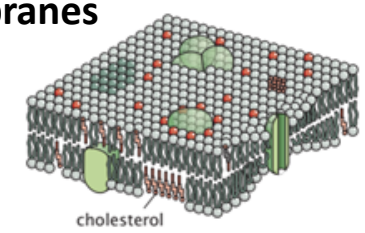
Prof. Stefania Rapino & Dr. Marco Malferrari, 1° year 2° semester

The course *Process of Cell Matter* will describe **the chemical principles governing cellular processes** and driving biological macromolecules activities; physiological and pathological cellular process will be considered.
Central cellular processes that can be targeted for specific drug delivery and the cellular properties which are fundamental in the development of innovative materials for tissue and organ engineering will be described:

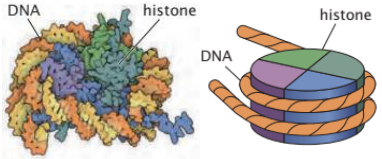
The Eukaryotic Cell: an overview

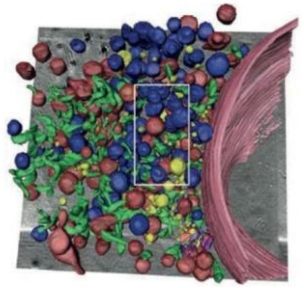


Lipids and biological membranes

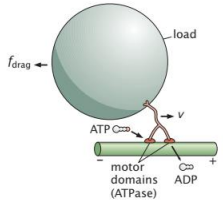


Nucleic acids

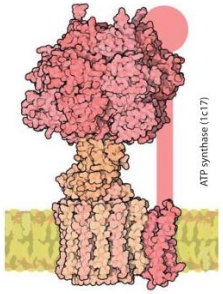


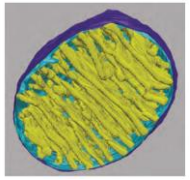


Cell trafficking and the secretory pathway: endoplasmic reticulum and Golgi

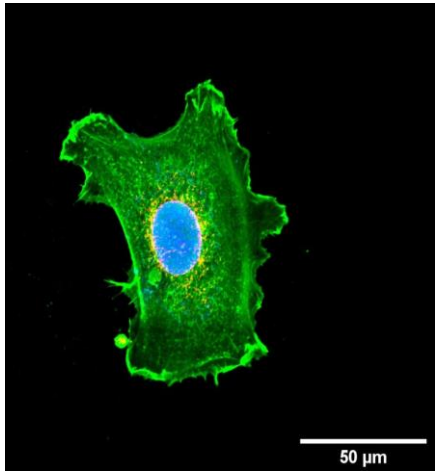


Structure-function relation in proteins. Molecular machines





Energy metabolism in the Cell

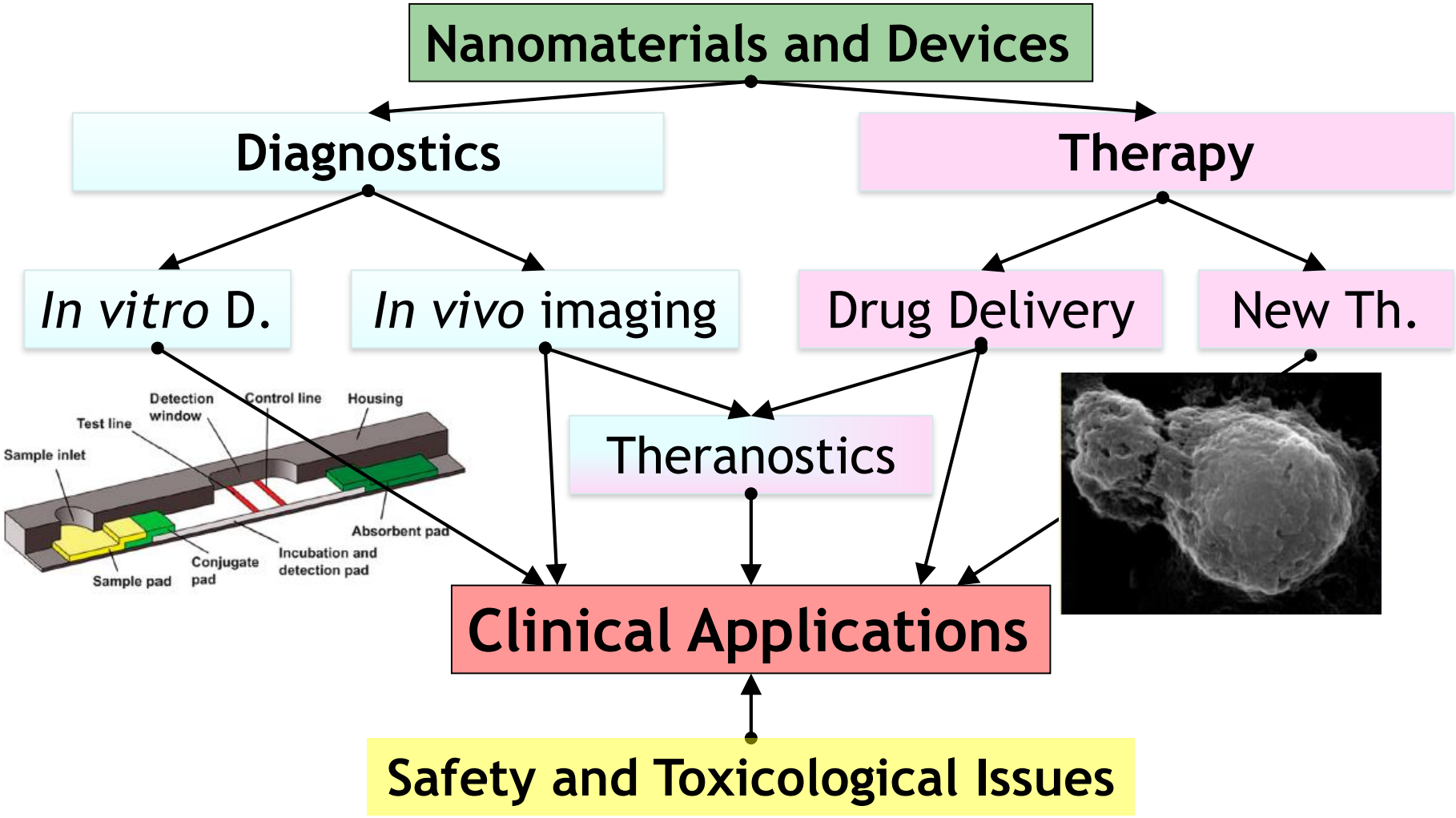


Laboratory practices: the students will perform practical activities concerning the topics discussed in the lectures and will learn and apply <u>quantitative treatment of physico-chemical measurements on biological systems.</u>

NANOMEDICINE

Prof. Luca Prodi, 2° year 1° semester

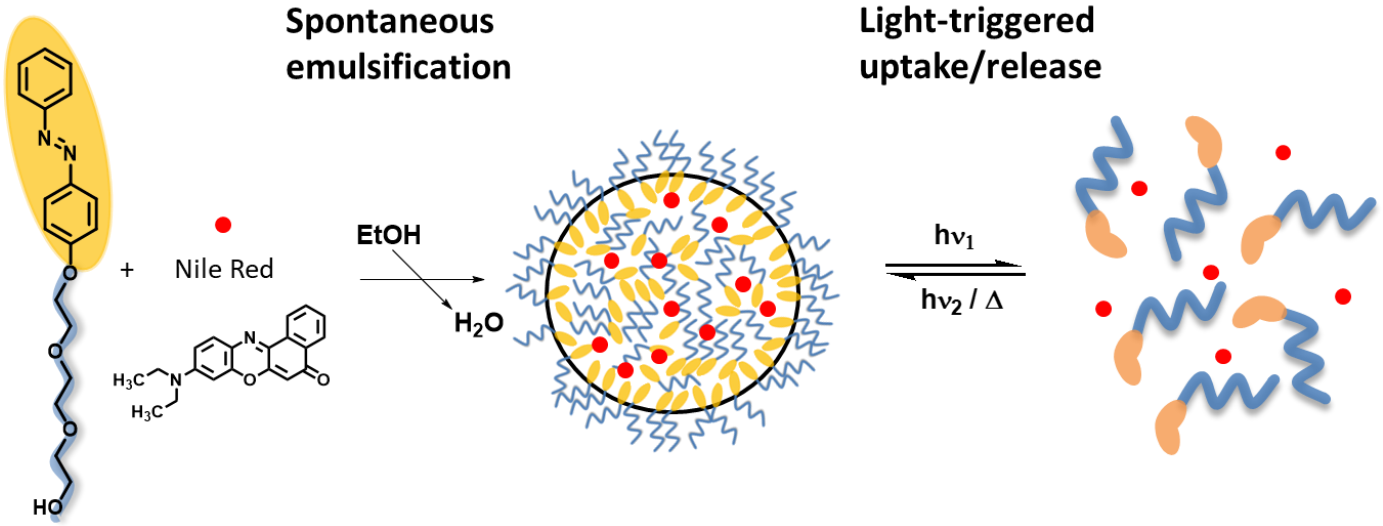
The field of Nanomedicine is the science and technology of **diagnosing**, **treating** and ***preventing*** disease and traumatic injury, of relieving pain, and *of preserving and improving* human health.



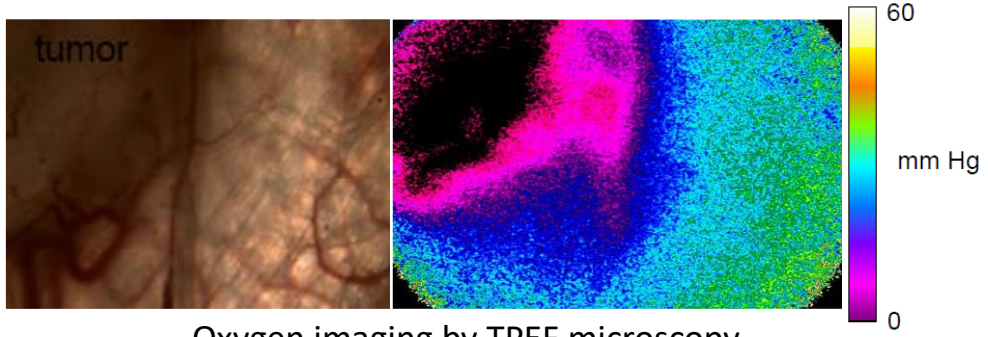
The key: design materials to address unmet medical needs where Nanomedicine can make the difference, **by providing currently lacking diagnostic and therapeutic options**.

SOFT AND LIGHT -RESPONSIVE MATERIALS
Dr. Marco Villa, 2° year 1° semester

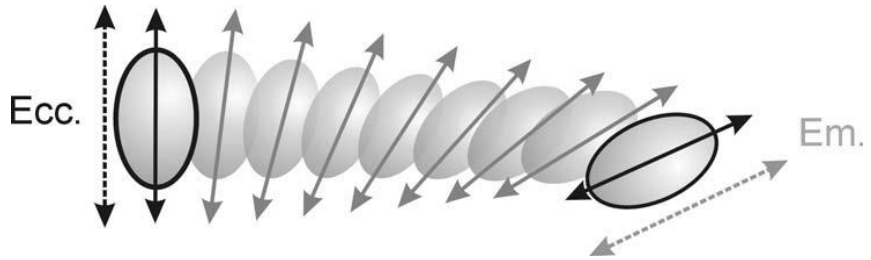
Stimuli-responsive materials are interesting for a variety of applications including contrast agents for imaging techniques, nanomedicine and drug delivery systems. These materials change their properties in response to one or more stimuli in their local environment, such as light, pH, magnetic fields or heat.



The course *SOFT AND LIGHT -RESPONSIVE MATERIALS* provides knowledge of the materials, the principal techniques and instrumentation, both in **steady-state or time resolved,** used for characterization of these innovative materials



Oxygen imaging by TPEF microscopy



Mechanisms for fluorescence anisotropy depolarization

Elective or free choice activities

- APPLIED BIOMATERIALS
- DIAGNOSTIC AND MICROFABRICATION TECHNIQUES FOR HEALTHCARE
- ASTROBIOLOGY
- BIOMIMETIC SUPRAMOLECULAR CHEMISTRY
- PHOTOBIOPHYSICS AND PHOTOBIOLOGY
- POLYMERIC MATERIALS FOR LIFE SCIENCE