

Share

Email destinataire :

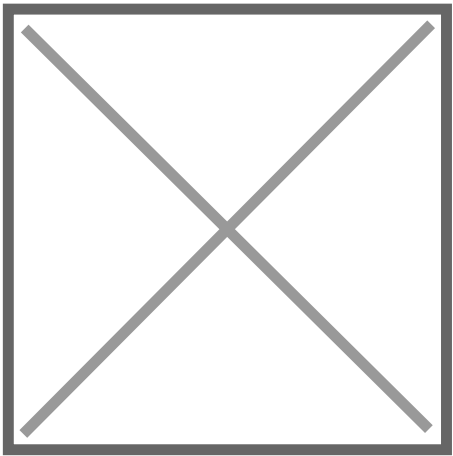
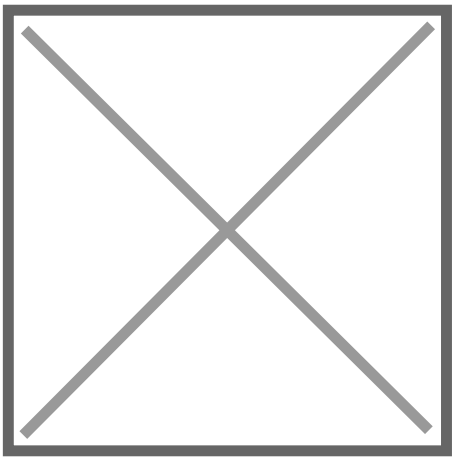
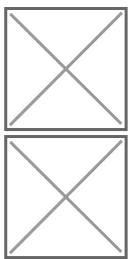
Vous devez renseigner un email valide

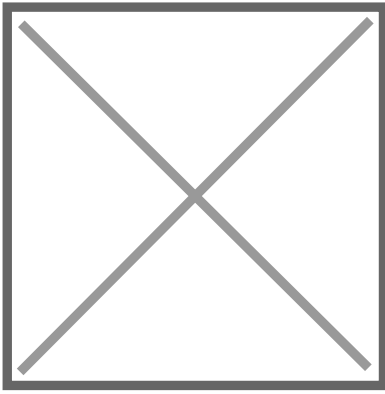
Envoyer

Une erreur est survenue. Merci de réessayer ultérieurement
Le mail de partage a bien été envoyé.

Add to Compare

M2 Physics, Engineering and Chemistry for Biology





Master's degree

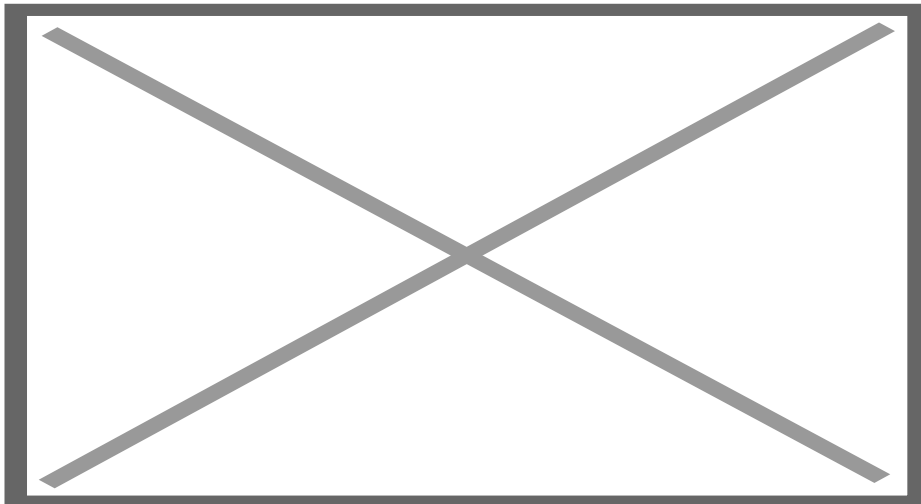
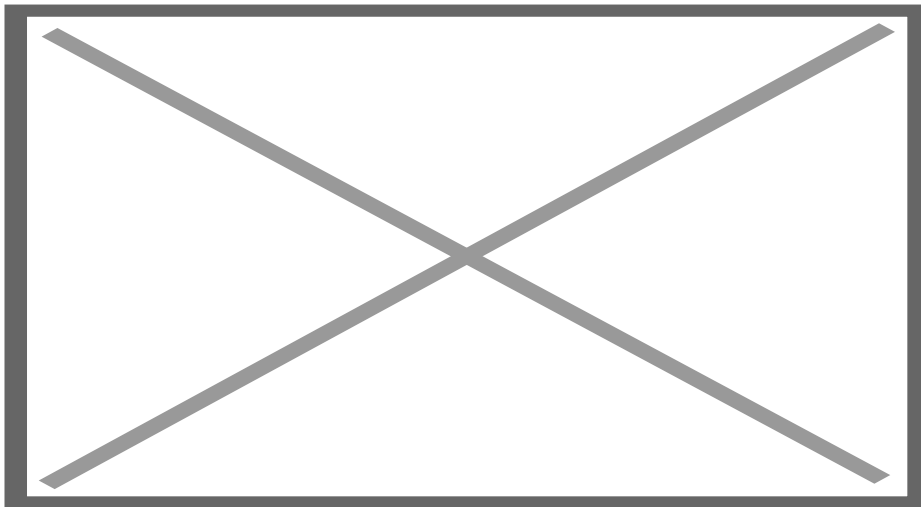
Specialisation Physique fondamentale et applications

Language(s) of instruction

English

[Télécharger la fiche détaillée](#)

[Apply Now](#)





Information

- [Overview](#)
- [Application requirements](#)
- [Schedule](#)

Présentation

Calendar

Start of programme (indicative date)

19/12/2025

Admission

Capacity

Available Places

24

Période(s) de candidature

Inception Platform

From 01/01/2026 to 20/07/2026

Supporting documents

Compulsory supporting documents

Copy of identity document.

Supporting documents (TOEFL, TOEIC, certificate of a teacher ...) of a level of a foreign language.

Motivation letter.

All transcripts of the years / semesters validated since the high school diploma at the date of application.

Curriculum Vitae.

Detailed description and hourly volume of courses taken since the beginning of the university program.

Additional supporting documents

Other diplomas.

VAP file (obligatory for all persons requesting a valuation of the assets to enter the diploma).

Programme

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di
Fundamentals in Biology	6	Semestre 1	41		10				

Fundamentals in Biology

ECTS : 6

Semester: Semestre 1

Detail

Lecture: 41

Practical study : 10

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

This course is mandatory for students having a limited background in Biology, (e.g. electrical engineers, computer scientists, mathematicians, physicists)

Programme/contents

- Structural biology methods
- Introduction to classical genetics/ mitosis and meiosis
- DNA replication and DNA repair
- DNA Transcription and translation
- Molecular biology methods
- Internal organization of eukaryotic cells and functions of organelles
- Cell signaling
- Eukaryotic Cell death and differentiation
- Diversity of the living world
- Cells in their social context: example of the immune system
- Introduction to microbiology: host-interaction (viruses, bacteria)
- Cellular biology methods
- Neurone: synaptic communication-electrophysiology
- Main functions of the brain and neurotransmitters

Learning objectives

To provide a basic training to non-biologists and to offer them a quick initiation to the various fields of life sciences. This training will allow students to choose biology-oriented modules of the Erasmus Mundus Master at the interface of physical sciences and molecular/cell biology.

Bibliography

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di
Practical works	3	Semestre 1			30				c
■									

Practical works

ECTS : 3

Semester: Semestre 1

Detail

Practical study : 30

Language(s) of instruction

Anglais

Remote teaching

non

Type of assessment

Evaluation Continue non Intégrale

«Core UE» 5 among 6

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di
Cell biochips	3	Semestre 1	17	6	8				c

Cell biochips

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 17

Practical study : 8

Directed study: 6

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

This course is open to multidisciplinary background students.

Programme/contents

1. Electrical monitoring of cells
 - Single cell electrical characterization using bioimpedance Maxwell-Garnett mixing theory, multishell model, single shell model, thick membrane simplified model, complex permittivity of the cell and the mixture, double layer capacitance of the electrodes, estimation of the cell parameters
 - Cell tissue characterization using impedance Fricke Model, Cole-cole model, phase constant element, estimation of the cell tissue parameters
 - Electromechanical characterization of cells : electrorotation of cells and vesicles, Clausius- Mossotti factor, fitting to a model,
 - parameter estimation, from bioimpedance or electrorotation measurements
 - Case of study cell impedance measurement on a chip (paper reading exercises)
2. Cell handling and sorting with the electrical field
 - Polarization of cells, principle of the dielectrophoresis
 - Cell trapping/sorting using the dielectrophoresis
 - Cases of study of single cell sorting on a chip (paper reading exercises)

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di le c
Fundamentals in Chemistry	3	Semestre 1	30						

Fundamentals in Chemistry

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 30

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

This course is mandatory for students having a limited background in Chemistry

Programme/contents

Part I: Molecular Chemistry

1. Chemistry of the Elements Models for atoms and electrons description. Electronic configuration. Periodic table and element properties.
2. Organic molecules Chemical bonds. Molecular structure and geometry. Aromaticity. Functional groups. Conformation and configuration.
3. Non-covalent interactions Ion-ion, ion-dipole, dipole-dipole, hydrogen bond, halogen bond, aromatic interaction, cation-?, anion-?, van der Waals

Part II: Physical Chemistry

1. Thermodynamics Enthalpy, Gibbs energy and entropy. Chemical equilibrium.
2. General Chemistry in Solution Acid, bases and pH. Complexation. Solubility and polarity effects.
3. Kinetics Reaction rate. Reaction mechanism. Catalysis
4. Basics of Surface Chemistry

Learning objectives

This course is an overview of important and fundamental aspects of chemistry. Basic principles, necessary to understand chemistry and contiguous scientific fields, are given

Bibliography

“Chemistry 2: Introduction to Organic Chemistry”

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di le c
BioMolecular Photonics	3	Semestre 1	28						

BioMolecular Photonics

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 28

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Fundamental in biology

Programme/contents

- Introduction to fluorescence / photoreactivity
- Time-resolved fluorescence analysis
- Fluorescent probes in biology
- Intrinsic fluorescence (e.g. protein fluorescence) & fluorescence quenching
- Steady state & time-resolved fluorescence anisotropy
- Fluorescence (cross)correlation spectroscopy
- Introduction to FRET (fluorescence resonance energy transfer) / FRET-FLIM
- Single molecule FRET – Introduction to TIRF microscopy
- Quantitative PCR
- Flow cytometry

Learning objectives

This course will provide theoretical knowledge required to understand experimental methods underlying fluorescence-based assays for biology at the molecular level: (i) photoluminescence & photoreactivity (excited state, (non)radiative relaxation pathways, photoisomerization...), (ii) steady-state & time-resolved parameters/methods, (iii) main intrinsic/extrinsic fluorescent probes used in biology and (iv) biological applications (quantitative PCR, flow cytometry). The students must have understood the principle of these techniques and to be able to master them quickly in an experimental environment

Bibliography

Joseph R. Lakowicz, Principles of fluorescence

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di le c
Light-matter interaction: from molecules to solids	3	Semestre 1	30						

Light-matter interaction: from molecules to solids

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 30

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Quantum physics, hydrogen atom, introduction to condensed matter (band structure of solids), Schrödinger equation, molecular orbitals, chemical kinetics

Programme/contents

Introduction: overview on the conceptual tools and phenomena From Schrödinger equation to ...
 Molecules: Molecular orbitals - Energy levels - Jablonski-Perrin diagram Solids: Band structure of semiconductors - Different dimensionalities: quantum well, quantum wire, quantum dot - Phonons in a solid Ground to excited states: light absorption Molecules: Selection rules - Transition moment - Molecular physicochemical properties at excited states Solids: Absorption coefficient: interband optical transitions, selection rules, density of states -Properties at excited states: excitons Excited to ground states: light emission and other mechanisms Molecules: Non-radiative relaxation mechanisms: vibrational relaxation, internal conversion, inter-system crossing - Photoluminescence (fluorescence and phosphorescence): quantum yield, lifetime, emission and excitation spectra Solids: Intraband non-radiative relaxation (electron phonon interaction) - Photoluminescence (electron-hole recombination): quantum yield, lifetime, emission and excitation spectra Complex processes Molecules: Fluorescence quenching - Energy transfer (FRET: Förster resonance energy transfer) Solids: Energy transfers - Charge transfers

Exercise sessions Seminars - Examples from research Molecules: Photochemical reactions and photo-active molecule Solids: Optical properties

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di le c
Advanced Microscopies	3	Semestre 1	28						

Advanced Microscopies

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 28

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

bases in fluorescence, ray optics, wave optics

Programme/contents

1: Fundamentals of optical microscopy Structure of an optical microscope, Köhler configuration, phase contrast imaging, depth of field, spatial resolution. 2: Fluorescence microscopy and super-resolution techniques: imaging with nanometer-scale resolution Based on examples with biological applications. 3: Deeper in tissue Use of multi-photon microscopy and adaptive optics. Examples from neurosciences. 4: Faster: how to image in real-time living samples Tracking methods, resonant 2-photon imaging, functional imaging.

Learning objectives

The aim of this course is to present different optical microscopy methods useful for studying biological samples at the cell and tissue scales. We will start by introducing the basics of optical microscopy (characteristics of a microscope objective, illumination configurations, notions of depth of field, resolution limits...). We will then turn our attention to fluorescence microscopy, and in particular to super-resolution techniques. Different techniques, such as STED, PALM or STORM will be presented. Compromises between spatial and time resolution will be discussed (structured illumination microscopy) as well as super-resolution in the optical-axis direction (PSF engineering). We will then see how multi-photon microscopy and adaptive optics provide a way to image deeper in the biological tissues. We will finally focus on fast imaging, to study live biological samples. Techniques as single-particle tracking and resonant two-photon imaging will be introduced

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	di le c
Soft Condensed Matter	3	Semestre 1	30						

Soft Condensed Matter

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 30

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

This course requires a good knowledge of Statistical Mechanics.

Programme/contents

Part I: Statistical Mechanics of Interacting Systems: Appl

1. Review of Stastical Mechanics Postulates of Statistical Mechanics, Gibbs Ensembles, from micro to macro. Ideal systems.
2. Non-Ideal Systems and Virial expansion
Ideal systems and they role in soft matter. Complexity and phase transition. A first treatment introducing the virial expansion.
3. Density Distribution Theory Introduction to the liquid state theory. Density distribution and radial distribution function (RDF). Connection of the RDF to thermodynamics properties. Stati structure factor. Brief introduction to computer simulations.
4. Scattering Theory Formal connection of the static structure factor with the scattering properties. Form factor. Performing scattering function in real life: SALS, SAXS, SANS. A brief introduction to Dynamic Light scattering (DLS)

Part II: Intermolecular interactions

1. Introduction Enthalpy, Gibbs energy and entropy. Chemical equilibrium.
2. van Der Waals interactions Origin, simple derivation, from microscopic to macroscopic interactions.
3. Electrostatic Interaction Poisson-Boltzman equation, Debye-Huckel Theory, DLVO interactions and aggregation

TDs: Applications

« Options » at least 2 among 4

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	dis c
Python	3	Semestre 1	9		21				

Python

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 9

Practical study : 21

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Basic Python programming; basic statistics.

Programme/contents

1. Programming Python basics 00
(Homework: 6h) Data types, control structures, lists, hashes, files
2. Data Manipulation using pandas Reading, storing and sharing large datasets, indexing/slicing/iterating, vectorization, dataframe operations.
3. Data Visualisation using matplotlib and seaborn Visualising data for exploration and for publication, data science traceability and reproducibility.
4. Exploratory Data Analysis using pandas and seaborn Finding relationships between variables, formulating hypotheses and devising models.
5. Basic statistical modelling using scikit-learn Constructing and training simple models to make predictions based on the data.
6. Personal/group project 8 Prepare a report about the exploratory analysis and statistical modelling of a real dataset (chosen by the students or proposed by the teacher)

Learning objectives

Python is a simple, multi-purpose language that is a reference in data science (statistical analysis of data and machine learning). This course focuses on the Python tools and libraries needed for high-performance manipulation, visualization and exploratory statistical analysis of large experimental datasets, as well as constructing and training statistical models to make

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	dis lea c
Modeling structure and dynamics of biomolecules	3	Semestre 1	15		15				

Modeling structure and dynamics of biomolecules

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 15

Practical study : 15

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Fundamentals in Biology, or equivalent prior knowledge

Programme/contents

CM:

1. Elements of quantum chemistry
2. The space of biological sequences and structures Multiple sequence alignments, conservation and (co-)evolution.
3. Protein structure prediction: physics and statistics The protein folding problem: approaches from physics (Anton) and statistics (AlphaFold).
4. Theoretical bases of molecular mechanics Biomolecular empirical force fields: principles, approximations, common functional forms, the solvent, performance considerations, applications.
5. Sampling the potential energy surface Algorithms and techniques (minimisation, Monte Carlo, molecular dynamics, Normal modes)

Lab Work 5. Quantum chemistry using Gaussian

6. Modelling structure From sequence to structure using machine learning; evaluating quality and limitations of models; using molecular viewers to study biomolecular structure and interactions and gain physical insight into the biological phenomena 7.

Modelling dynamics From static structure to trajectory in physiological conditions; extracting useful information from the trajectory to evaluate simulation quality, compare with experiment and shed light on molecular mechanisms

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	dis lea c
Image analysis for biology	3	Semestre 1	30		4				

Image analysis for biology

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 30

Practical study : 4

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

This course is open to multidisciplinary background students.

Programme/contents

1. Super resolution for bio-microscopy
2. Cell detection : MorphoMat, image aspect, thresholding, segmentation (K-MEANS), De-noising
3. Cell tracking : Estimation movement, optical flow
4. Introduction to AI: ResNet Practicals – Laboratory Introduction to image processing, application to a case study (cell detection and counting)

Learning objectives

The objective of the course is to acquire the basic notions of signal and image processing in order to be able to solve imaging problems of biological structures. We will study the principles of obtaining super-resolved imaging approaches and partially overcoming light diffraction problems. But we will also study the problem of image processing in order to create automatic image processing. Finally, we will study sequences in order to solve cell tracking problems.

Overall organisation

The course will present the necessary aspects of information theory to understand the different existing super-resolved microscopy systems. The main image processing methods allowing the detection and identification of biological objects will be presented and manipulated (for example automatic thresholding methods, mathematical

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	dis lea c
Laser and Nonlinear Optics	3	Semestre 1	22	8					

Laser and Nonlinear Optics

ECTS : 3

Semester: Semestre 1

Detail

Lecture: 22

Directed study: 8

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Optical physics and electromagnetism, Laser (Bachelor level)

Programme/contents

- Review of lasers ? working principle ? main properties, intensity ? different kinds of laser ? main applications
- Introduction to nonlinear optics ? general idea ? reminder of linear optics ? a classical model for nonlinear effects
- Nonlinear of bulk systems – coupled-wave theory ? propagation equation ? a fully treated useful example: non-resonant second-harmonic generation, phase matching and phase mismatching
- Second-order and third-order nonlinear optics ? Second-harmonic and third harmonic generation ? Parametric amplification, Pockel and Kerr effects, etc.
- Nonlinear optics in micro- and nano-structures ? Quasi-phase matching technique: structures 1D, 2D and 3D ? Nonlinear photonic crystals: perfect phase matching. ? Fabrication and applications of nonlinear photonic crystals
- Nonlinear microscopies and nanoscopies ? What does (or does not) matter from bulk to nanoscale ? Multi-photon microscopies in nanophotonics and biosciences: SHG, TPE, THG, T3FE, CARS, EO, STED, structured illumination, ...

Learning objectives

First to give basics of nonlinear optics and its applications to laser technology and applications. Second, to explore the relatively recent domain of nonlinear optics from to micro towards the nanoscale, including nonlinear effect in micro and nanostructures, nonlinear photonic crystals, as well as some far-field nonlinear microscopies and nanoscopies. Applications in physics and

« Options » at least 3 among 5

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class
Tissues and Bioengineering	3	Semestre 2		30				
■								

Tissues and Bioengineering

ECTS : 3

Semester: Semestre 2

Detail

Directed study: 30

Language(s) of instruction

Anglais

Remote teaching

non

Type of assessment

Evaluation Terminale

Quantum sensing	3	Semestre 2	30
---------------------------------	---	------------	----



Quantum sensing

ECTS : 3

Semester: Semestre 2

Detail

Lecture: 30

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Quantum mechanics and basics of light-matter interaction

Programme/contents

General Introduction Light-Matter Interaction
reminders: Optical Bloch equations and Bloch sphere: how to manipulate a Qubit? Notion of decoherence and decoherence in a quantum sensing experiment Introduction to classical noises in measurements Noise in a quantum sensing experiment • NV centers in diamond basics and optically detected magnetic resonance (ODMR) • Applications of ODMR to magnetometry and thermometry: continuous wave regime and pulsed regime (Ramsey interferometry) • Some physical and biomedical applications of NV-diamond magnetometry and thermometry • Decoherence in NV-center in diamond and application to sensing of biophysical parameters

Learning objectives

Understand how quantum states can improve the sensing of properties of different systems, and what are the limitations of quantum measurements. The concepts will be illustrated by examples of applications in physics and biology mostly based on nitrogen-vacancy centers in diamond.

Overall organisation

Each time slot is separated into a concept introduction and tutorials, often illustrated by scientific papers. The aim of the course is to highlight classical limits that can be overcome by a quantum approach of the measurements. The first part of the course will be dedicated to the notion of quantum bit and how to use it to measure an external parameter such as temperature, electric or

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	0
ICR - Ion Channel Recording and nanopore technology	3	Semestre 2	22	6	4				

ICR - Ion Channel Recording and nanopore technology

ECTS : 3

Semester: Semestre 2

Detail

Lecture: 22

Practical study : 4

Directed study: 6

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

This course is open to multidisciplinary background students.

Programme/contents

1. DNAchip concept of successive photoexposures to develop high throughput chips
2. The electrical field within the cell

- Basics in electrophysiology,
- Huxley model of action potential propagation, Simulation of the Action potential (practicals), Resolution of the propagation of electrical signal (co-axial cable vs Axon)

3. Electrical monitoring of ion-channels

- Main systems for ion channel recording, patch clamp, planar patch clamp,
- Artificial lipid bilayers systems: Structure and fabrication of membrane protein chip, Liposomes, Giant liposomes, electroformation, droplet contacting method
- Architecture and clean room microfabrication of the microfluidic devices for ion-channel recording
- Paper reading exercise

4. Nanopore sensing technology

- Use of biological nanopores for the single molecule sensing
- Use of solid state nanopores for large molecules sensing
- Paper reading exercise Practical

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	C
Microfluidics	3	Semestre 2	18	4	8				

Microfluidics

ECTS : 3

Semester: Semestre 2

Detail

Lecture: 18

Practical study : 8

Directed study: 4

Language(s) of instruction

Anglais

Remote teaching

non

Programme/contents

1. Introduction

- Scaling laws in Microsystems

2. Microfluidic technology

- Clean room, Photolithography and Microelectronics technology glass, silicon, polymer (molding-casting)

3. Physics of microfluidic

- Poiseuille flow
- hydrodynamic separation: wall effect, shear stress effect - Diffusion and mixing
- Capillarity: digital microfluidics – Droplet
- Case of study exercises

4. Microfluidics for the cell sorting and characterization

- Acoustophoresis of cells in microfluidic devices
- Magnetophoresis in cell chips
- Dielectrophoresis separation within microfluidic devices
- Amperometric sensing / convection-diffusion-consumption
- Case of study (research paper reading exercises) Practical training (8h)
- Fabrication and testing of a micromixer in PDMS
- Droplet generator and phase diagram characterization MODULE TP: Microfluidic sorting using hydrodynamic forces

Learning objectives

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	0
Nanophotonics	3	Semestre 2	30						

Nanophotonics

ECTS : 3

Semester: Semestre 2

Detail

Lecture: 30

Language(s) of instruction

Anglais

Remote teaching

non

Prerequisites

Optical physics and electromagnetism (L3 level), basic mathematical physics notions in classical and quantum mechanics (L3 level), and Light-matter interactions course (M1 level)

Programme/contents

- PART ONE: Photonic crystals/nonlinear photonic crystals and applications ? 1D, 2D, and 3D photonic crystals: theory, simulation ? Photonic crystal and photonic quasi-crystals ? Photonic crystal with defect and applications ? Nonlinear photonic crystals ? Fabrication technologies and applications

- PART TWO: Plasmonic effect ? Electromagnetism and optics in bulk noble metals: Electromagnetism survival kit; Bulk noble metals: Electronic properties, optical response ? Localised plasmon in metal nanoparticles: Mechanical analogy: driven damped linear oscillator; Dielectric confinement; local field enhancement; applications for Surface-enhanced Raman scattering or fluorescence; bio-labelling; Effects of nanoparticle environment, size, shape and composition; Coupling between nanoparticles. ? Transient optical response and nanoscale light-heat conversion: Metal nanoparticles under laser pulses: Light-heat nanometric conversion; Thermo-optical properties ? Selected applications: Light-heat conversion: Nanoscale hyperthermia against cancer, drug or DNA delivery, laser damage and laser shaping, photothermal imaging, optical limitation

- PART THREE: Single molecules ? Energy levels in molecular systems; Light-matter interaction (from two level system to molecules) ? Single molecule spectroscopy: confocal spectroscopy, photon statistics. ? Single Molecules for

Final Internship

Subjects	ECTS	Semester	Lecture	directed study	practical class	Lecture/directed study	Lecture/practical class	directed study/practical class	distance learning
M2 final internship	21	Semestre 2							
■									

M2 final internship

ECTS : 21

Semester: Semestre 2

Language(s) of instruction

Anglais

Remote teaching

non

Type of assessment

Evaluation Continue Intégrale

Contact

- **François TREUSSART**

<http://www.universite-paris-saclay.fr/formation/master/physique-fondamentale-et-applications/m2-physics-engineering-and-chemistry-biology>