

## Contact & Information

### Master BME-Paris

Centre universitaire des Saints-Pères  
45 rue des Saints-Pères  
75006 Paris  
France

[contact@bme-paris.org](mailto:contact@bme-paris.org)

 <http://www.bme-paris.org>

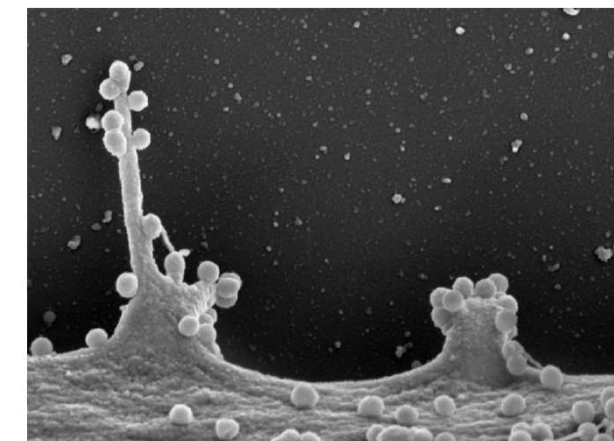
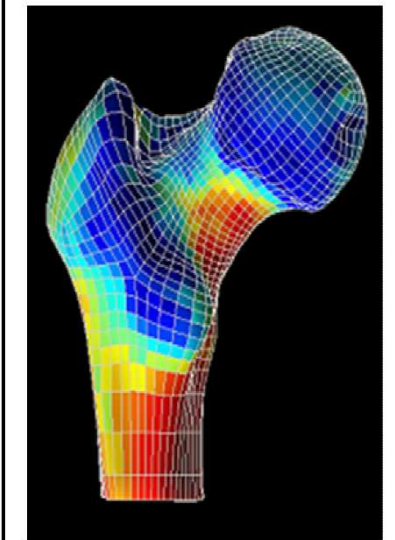


Editors: Pr. W. Skalli, Pr. R. Barouki  
Content design: S. Laporte, F. Collin  
Paris Descartes / ParisTech, June 2010

Photos: [p1] © Inserm, P. Roingard (44632) [p2] © Inserm, P. Latron (45106) / C. Vidal [p3] © Inserm, P. Latron (45709) / CRI Paris / T. Milosevic, CRI Paris [p4] LBM, Arts et Métiers ParisTech / CRI Paris [p5] © Inserm, M. Depardieu (6673) / © Inserm, P. Latron (45597) [p6, p7] C. Oppenheim [p8, p9] C. Vidal / C. Oppenheim / E. Angelini / F. Cloppet [p10] Y. Yang, CRI Paris / © Inserm, T. Couderc (23109) / S. Adiba, CRI Paris [p11] L. Ciriani, CRI Paris / © Inserm, D. Dantchev (6792) [p12] © Inserm, L. Simonneau (43866) / S. Hacein-Bey [p13] © Inserm, P. Latron (45735) / S. Hacein-Bey [p14, p15] LBM, Arts et Métiers ParisTech [p16] LBM, Arts et Métiers ParisTech [p17] © Inserm, D. Chappard (44617) / © Inserm, A. Guillaume (11109) [p18] LBM, Arts et Métiers ParisTech [p19] © Inserm, A. Rouche (5334) / © Inserm, G. Boivin (22811) / © Inserm, M.-C. Hobatho (9973) [p20] © Inserm, A. Rouche (8567) [p21] F. Cloppet [p22] © CNRS Photothèque, S. Godefroy (2009N01240) / © Inserm, P. Latron (46296) [p23] © CNRS Photothèque, H. Raguet (2004N00440) / © Inserm, P. Latron (45457) [p24] F. Collin

# BioMedical Engineering

## Master's Degree Program



 UNIVERSITÉ  
PARIS DESCARTES

*bme*  
Paris  
BioMedical Engineering  
MASTER PROGRAM

ParisTech  
INSTITUT DES SCIENCES ET TECHNOLOGIES  
PARIS INSTITUTE OF TECHNOLOGY

# BioMedical Engineering Master's Degree Program

## Chairpersons

**Professor Wafa Skalli, PhD**  
Arts & Métiers ParisTech

**Professor Robert Barouki, MD, PhD**  
Université Paris Descartes

The BME-Paris Master's Degree Program offers two years of academic and professional training in bioengineering, a burgeoning field at the crossroads of the biomedical and engineering sciences. This program results from a partnership established between Paris-Descartes University and the Paris Institute of Technology (ParisTech), a member of the IDEA League of European science and technology universities.

Firmly based on an interdisciplinary approach, the BME-Paris Master's relies on international collaboration and features strong student initiative. These principles are strengthened by the complementary competencies of the program's two outstanding academic partners: Paris-Descartes in the biomedical and health sciences and ParisTech in the engineering sciences.

This jointly sponsored program offers a high-quality curriculum to students arriving from a broad range of academic backgrounds: biology and biochemistry, medicine, chemistry, physics, engineering, mathematics and computer science, etc... The aim of the BME Paris Master's is to provide students with the tools and capacities that will enable them to function in a broad range of biomedical engineering applications that today rank among the most scientifically innovative and rapidly developing areas of academic research, industrial R&D, and the clinical environment.

## Assets available

- High-profile teaching staff: research specialists of international stature
- Interdisciplinary research projects and seminars
- Unique student environment at Paris-Descartes and ParisTech
- Individual, tailor-made support for students

Students can take advantage of the international partnerships of Paris-Descartes and ParisTech, including the Idea League program, a Europe-wide network of leading science and technology universities and engineering schools (Imperial College London, Technische Universiteit Delft, Eidgenössische Technische Hochschule Zürich, Rheinisch-Westfälische Technische Hochschule Aachen, as well as ParisTech).

## Skills taught

- Use of interdisciplinary approaches in developing innovative research projects in bioengineering fields
- Planning and conducting scientific / technological projects; analysis, diagnosis, modeling, experimental protocols, result interpretation
- Oral and written scientific communications for international conferences and peer-reviewed journals
- Adapting to professional environments; teamwork, adjusting to new or different contexts and corporate cultures
- Scientific and medical ethics

## Professional opportunities

The BME-Paris Master's program provides high-quality graduate education in scientific research, including lecture courses, seminars, and laboratory training by internationally recognized scientists. The program prepares students for positions in academia (teaching and research), industry (R&D), and the clinical environment (healthcare).

Other opportunities are available through the close partnership that exists between Paris-Descartes and ParisTech. At the end of the first year, BME students may apply to continue for a second year at other ParisTech schools. At the end of the second year, students from a nonmedical background may apply for entry into the third year of medical studies at Paris-Descartes.

## Admission

Applications for admission to the BME-Master's Degree program are reviewed by an admission committee consisting of members of the program's international teaching staff. The application form may be downloaded from the following web site: <http://www.bme-paris.org>

## Entrance requirements

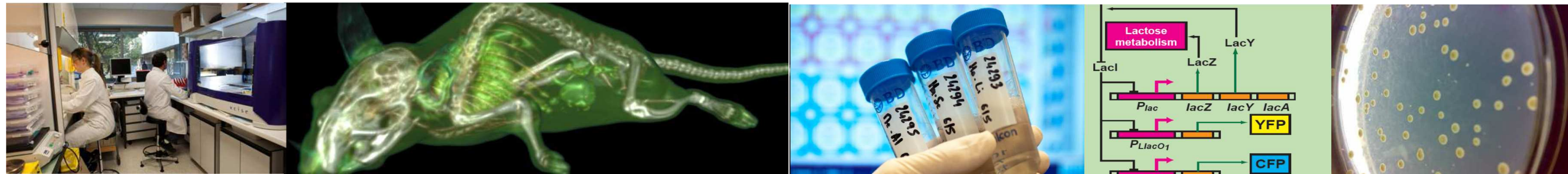
This BME-Paris Master program is open to highly motivated students of all nationalities, with life and health science curriculum. Admission can be considered at either M1 or M2 level (see details on [www.bme-paris.org](http://www.bme-paris.org)).

## Language requirements

All courses and examinations are in English. Applicants must read, speak, and write English fluently.

## Location

All teaching sites are located in the heart of Paris.



## MASTER 1 (semesters 1 & 2)



## MASTER 2 (semesters 3 & 4)

- Bioimaging (BIM)**  
*Imaging from Molecule to Human (IMH)*  
*Imaging Modalities & Processing (IMP)*
- Systems & Synthetic Biology, Information & Interaction (S2I2)**
- Molecular & Cellular Biotherapies (MCB)**
- Biomechanics & Biomaterials (BM<sup>2</sup>)**  
*Impact & Injury Mechanisms (I2M)*  
*Biomaterials & Biological Materials (B2M)*  
*MusculoSkeletal System (MS2)*  
*Biofluid & the Cardiovascular System (BCS)*  
*Neuroengineering (NEC)*  
*General BioMechanics (GBM)*
- Industrial Bioengineering (IBE)**

## Master 1<sup>st</sup> year

### Chairpersons

**E. Angelini**, PhD  
Telecom ParisTech

**F. Collin**, PhD  
Université Paris Descartes

master1@bme-paris.org

The first year of the BME-Paris Master's (M1) is intended to strengthen and broaden students' capacities in specific engineering and biomedical subjects.

Considering the wide variety of academic origins and backgrounds of the students, five 6-credit (ECTS) courses (UE) chosen from among the eight offered must be taken during the first semester of the M1 year in order to fill-in gaps in individual students' capacities in a wide spectrum of fundamental science subjects. For example, an engineering graduate would be required to take Anatomy & Physiology and a life-science or medical school graduate would have to follow courses in signal-processing and solid or fluid mechanics.

In preparation for their 2nd year of studies (M2), students must select one or several pre-specialization courses (a total of five are proposed) during the second semester.

### Core courses

#### Third semester

UE 1.0 - Seminars, projects, language, culture
UE 1.1 - Anatomy & Physiology
UE 1.2 - Life chemistry & biocompatibility
UE 1.3 - Molecular, cell & tissue biology
UE 1.4 - Medicine & science
UE 1.5 - Statistics for systems biology
UE 1.6 - Fluid & solid mechanics
UE 1.7 - Computational biology
UE 1.8 - Physics for biomedical imaging
UE 1.9 - Advanced organic chemistry
UE 1.10 - Mathematics & informatics
UE 1.11 - Applied mathematics for signal processing

#### Fourth semester

UE 2.1 - Scientific communication
UE 2.2 - Economy & management
UE 2.3 - Physics for biology
UE 2.4 - Pre-specialization : BIM, S2I2, MCB, BM <sup>2</sup> , IBE
UE 2.5 - Lab training, research internship, tutored projects



# BioImaging (BIM)

## Chairpersons

**F. Cloppet**, PhD  
Université Paris Descartes

**Pr. C. Oppenheim**, MD, PhD  
Université Paris Descartes

**E. Angelini**, PhD  
Telecom ParisTech

BIM@bme-paris.org

Bioimaging is an exciting and growing field overlapping the interfaces of engineering, mathematics and computer sciences, as well as chemistry, physics, life sciences, and medicine. The main goal of bioimaging is to improve human health by using imaging modalities to advance diagnosis, treatment, and prevention of human diseases.

The BIM track offers high-level interdisciplinary education and training supported by the complementary skills of Paris-Descartes and ParisTech. A large network of research laboratories provides students access to industrial and experimental imaging systems that utilize innovative technologies.

The BIM track is accessible to engineering and life-science students (medicine, pharmacology, biology, chemistry, biochemistry, physics) preparing for career paths in academic research or industrial R&D environments. It relies on close collaboration between Paris-Descartes and several ParisTech engineering schools (Telecom, ENSTA, Mines, Arts et Métiers, IOGS, ESPCI, Polytechnique, Chimie.) The BIM curriculum consists of fifteen courses (UE) at the M2 level that are organized, taught, and overseen by faculty members expert in the appropriate fields.

During the M2 year, students select two 6-ECTS courses (UE) from a core syllabus, two 3-ECTS UE for specializing in one of the two subtracks (IMH and IMP), and one 6-ECTS or two 3-ECTS additional UE(s) in one of the subtracks or in the common-core, or even in another track. The set of each student's elective courses is determined according to his/her professional objectives and approved by the BME-Paris Master's committee.

The bioimaging track places strong emphasis on the basic sciences (mathematics, physics, chemistry) and applied mathematics (signal-processing, numerical analysis).

## Core courses

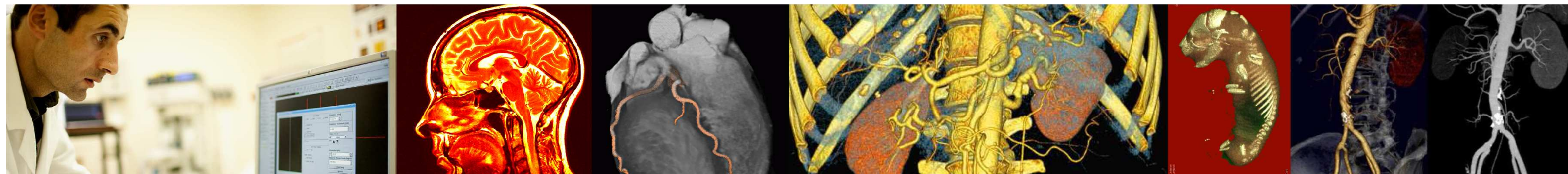
### Third semester

<b>UE 3.0</b> – Seminars & conferences
<b>UE 3.1</b> – Interdisciplinary week
<b>UE 3.2</b> – Optical imaging – level 1
<b>UE 3.3</b> – Medical image analysis – level 1
<b>UE 3.4</b> – Diagnostic imaging
<b>UE 3.5</b> – Chemistry for imaging
<b>UE 3.6</b> – Technology of medical imaging

### Fourth semester

<b>UE 4.0</b> – Ethical aspects of bioengineering
<b>UE 4.1</b> – Economical & industrial aspects
<b>UE 4.2</b> – Lab training, research internship

- A. Imaging Modalities & Processing (IMP)
- B. Imaging from Molecule to Human (IMH)



## Subtrack « Imaging Modalities & Processing (IMP) »

### Contact

**Elsa ANGELINI**  
Telecom ParisTech

**Pr. Catherine OPPENHEIM**  
Université Paris Descartes

IMP@bme-paris.org

### Subtrack courses

**UE 3.7b** – Optical imaging – level 2

**UE 3.8b** – Acoustics & electromagnetics for imaging

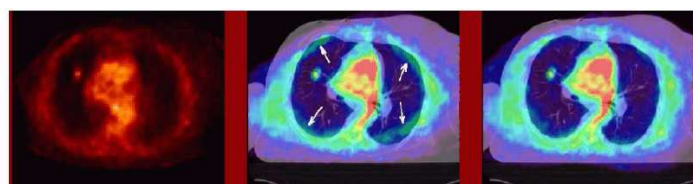
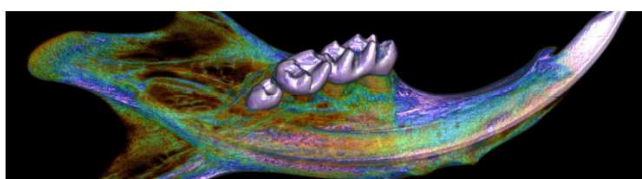
**UE 3.9b** – Tissue optics and laser interaction

**UE 3.10b** – Medical image analysis – level 2

The Imaging Modalities and Processing (IMP) track provides robust training to engineers, scientists, and physicians in the domain of medical and biological imaging modalities and image processing methodologies for computer-based data extraction and interpretation, and for diagnosis, as well as for their innovative uses in novel applications, such as therapeutic treatments, laser surgery, and *in-vivo* optical screening. IMP courses provide students with solid technical training in the physics of medical imaging modalities, technologies involved in various acquisition systems, and image processing methods for the extraction of anatomical and biological information. There is a special focus on the quantification of image-based information and image-based modeling of biological and anatomical structures.

Teaching is mainly provided by engineering faculty, researchers, and physicians working in radiology who are highly familiar with technical innovations related to computational methods, imaging systems, and innovative therapies. A wide network of research laboratories at ParisTech and ParisDescartes partner establishments affords students access to industrial and experimental imaging systems and acquire training in handling of such systems.

The training offered in the IMP track will qualify students for employment in the broad biomedical imaging sector, which includes industrial manufacturing (whole-body scanners and microscopic systems), image-processing software editing, and R&D departments that use biomedical image processing tools (e.g., pharmaceutical and cosmetic groups), or to pursue study toward a Ph.D. degree in applied mathematics, computer science, physics, and medical science. Medical students will acquire training in biomedical imaging that will enable them to manipulate a wide variety of screening modalities and to master image processing tools for clinical research.



## Subtrack « Imaging from Molecule to Human (IMH) »

### Contact

**Florence CLOPPET**  
Université Paris Descartes

**Pr. Catherine OPPENHEIM**  
Université Paris Descartes

IMH@bme-paris.org

### Subtrack courses

**UE 3.7a** - Chemistry level 2 : molecular tools for imaging

**UE 3.8a** - Advanced biology for imaging

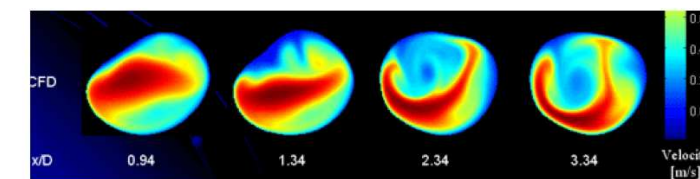
**UE 3.9a** - Medicine: molecular imaging

**UE 3.10a** - Medicine: function and metabolism imaging

The Imaging from Molecule to Human (IMH) track is intended to provide solid multidisciplinary training (physics, pharmacology, chemistry, biology, medicine, and image-processing), with a major focus on imaging, in order to prepare BME students to pursue a career path in academic research or industrial research and development. The IMH track will enable students with backgrounds in the life-sciences, medicine, and material sciences to acquire a broad spectrum of knowledge in biological and medical imaging, providing them with a broad prospective of the domain and the high-level technical skills needed to devise novel and innovative solutions.

This track offers a unique combination of courses, involving instructors from various fields, including particle and molecular imaging, biology, medicine, image acquisition systems and physics principles, as well as image processing for computer aided diagnosis. Courses are taught by engineers, researchers, university faculty, and physicians specialized in radiology, from ParisTech and the PRES Sorbonne Paris Cité, group of university-level institutions in the Paris area. This diversity enables students to gain specific training in innovative technologies within the biological and medical imaging domain.

This high-level interdisciplinary education program qualifies students to seek jobs in industry (Research & Development departments) and to pursue their education towards a Ph.D. degree.



# Systems & Synthetic biology, Information & Interactions (S2I2)

## Chairpersons

**A. Lindner**, PhD  
Université Paris Descartes

**P. Hersen**, PhD  
Université Paris Diderot

S2I2@bme-paris.org

This track is shared with the 'Interdisciplinary Approaches to Life Sciences' - cursus Liliane Bettencourt master program of Paris Descartes & Paris Diderot Universities (aiv-paris.org).



The "Systems & Synthetic biology, Information and Interactions" track (S2I2) offers an interdisciplinary curriculum in integrative biology, focusing on the emerging fields of systems biology and synthetic biology, as well as on the interface between the web sciences (Information and Communication Technologies, ICT) track and medicine, health, and life sciences. It applies quantitative experimental and modeling tools to the study of fundamental aspects of systems that are larger than their parts (*e.g.*, genetic and social networks and the web).

The often-quoted credo of the Nobel Prize-winning physicist, Richard Feynmann, "What I cannot create, I do not understand," represents another pillar of the master -- learning to apply knowledge to create new systems. This is represented by the synthetic biology or the TIC options of this track. Within S2I2, students can choose between "systems and synthetic biology" and "web science interface" options, for which appropriate S2I2 courses are offered.

The importance of these emerging themes is evident from the growing number of high-profile scientific publications, dedicated research institutes, and startups. The link between the life-sciences and ICT is manifested in the growing interest in personalized medicine, web-based detection of epidemics, e-health, etc.

The originality of S2I2 is its interdisciplinary approach, based on active collaboration among students from different backgrounds (engineering, biology, medicine, physics, mathematics, chemistry, computer science, humanities...). S2I2 amounts to *training for research through research*. This track consists of three 14-week internship rotations (at least one experimental and one theoretical), as is the case in leading life-science graduate programs around the world. We strongly encourage students to do one internship in the private sector. Another internship may be in a laboratory outside France. The internship rotations enable students to acquire a wide spectrum of state-of-the-art concepts and technical competence. They also encourage students' initiatives in creating their own research projects (which are often too compartmentalized,) including cross-disciplinary collaboration. In parallel, students take courses that cover a wide-range of themes and participate in seminars and web 2.0 interactions aimed at developing critical thinking, scientific questioning, and project design.

*Environment:* Students in the S2I2 track benefit not only from the rich interactions available in the BME-Paris master's program, but also from the wealth of activities hosted by the Center for Research and Interdisciplinarity (CRI; cri-paris.org), which hosts both AIV master's program and the Liliane Bettencourt Frontiers of Life Sciences (FdV) PhD program.

## Elements of preparation for professional life and research:

S2I2 is designed to provide scientists, physicians, and engineers with an excellent education in emerging life-science disciplines. S2I2-track students are trained in a broad range of the life sciences, learn to be autonomous, and acquire the capacity to be innovative. They are provided opportunities to explore links in medicine, engineering, physics, chemistry, mathematics and computer science, the aim of taking leadership roles in public and private research establishments. Job opportunities for S2I2 graduates are available in academia and in innovative biotechnology enterprises, as well as in information science and the web-sector.

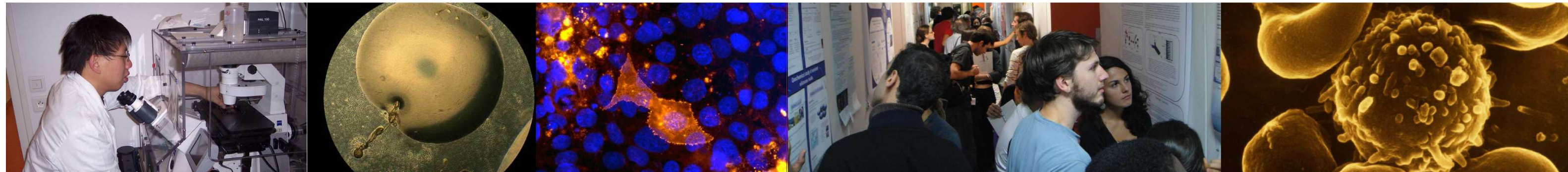
## Core courses

### Third semester

<b>UE 3.0</b> – Seminars & conferences
<b>UE 3.1</b> – Interdisciplinary week
<b>UE 3.2</b> – Analysis of articles concerning S2I2
<b>UE 3.3</b> – Bibliographic review of an interface subject
<b>UE 3.4</b> – Networks & dynamics
<b>UE 3.5</b> – Synthetic biology
<b>UE 3.6</b> – Rotating internship 1 (3 mo.)

### Fourth semester

<b>UE 4.0</b> – Ethical aspects of bioengineering
<b>UE 4.1</b> – Analysis of scientific books
<b>UE 4.2</b> – ICT and health
<b>UE 4.3</b> – Rotating internship 2 (3 mo.)
<b>UE 4.4</b> – Rotating internship 3 (3 mo.)



# Molecular & Cellular Biotherapies (MCB)\*

Chairperson

**Pr. S. Hacein-Bey-Abina,**  
PharmD, PhD  
Université Paris Descartes

MCB@bme-paris.org

The MCB track concerns two major categories of biotherapeutics applications: cell and gene therapy, and biopharmaceuticals.

Cell and gene therapy differs from drug therapy in that it concerns the use of "custom" or "à la carte" therapeutic agents created for a individual patients, a domain in which few manufacturers operate. Biopharmaceuticals are complex macromolecules created by biotechnology, and involve genetic manipulation of living organisms, which differ from conventional chemically synthesized small molecules.

The specific pharmacological and immunological features of biotherapy products, considered to constitute a new generation of drugs, are studied in conjunction with the characteristics of target populations, clinical follow-up, and biological monitoring.

The aim of this track is to train students of advanced scientific level in the field of biotherapy in order to prepare for careers in academia. These students may also find opportunities in industry at the national, European, and international level, particularly in biotechnology and medical research laboratories in teaching hospitals), as well as in cell and gene therapy firms.

The MCB program is divided into several course units. The first one covers the background and fundamental biological concepts needed to understand the various biotherapeutic approaches. It also provides an introduction to biological considerations involved in the use of therapeutic tools. The second unit addresses each biological system individually. The remaining two units deal with the study of specific examples, industrial aspects, and regulatory issues involved in the use of various types of biotherapeutic tools, as well as to clinical applications.

## Core courses

Third semester

**UE 3.0 – Seminars & conferences**

**UE 3.1 – Interdisciplinary week**

**UE 3.2 – Fundamentals of biotherapy, level 1**

**UE 3.3 – Fundamentals of biotherapy, level 2**

**UE 3.4 – Biological tools for biotherapy**

**UE 3.5 – Cell & tissue biotherapy, level 1**

**UE 3.6 – Industrial, biotechnological & pharmaceutical strategies**

Fourth semester

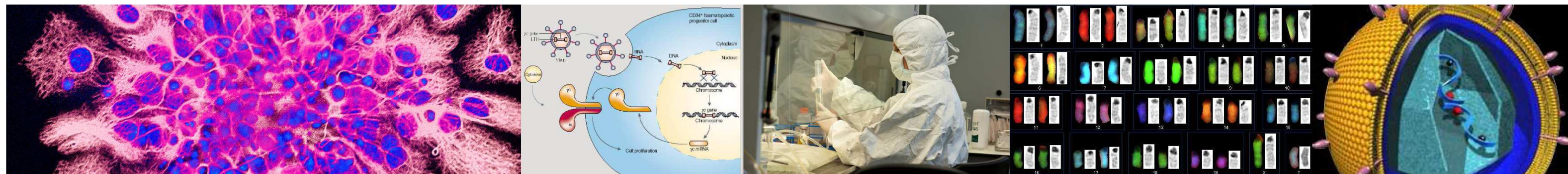
**UE 4.0 - Ethical aspects of bioengineering**

**UE 4.1 - Clinical & regulatory aspects**

**UE 4.2 - Cell & tissue biotherapy, level 2**

**UE 4.3 - Lab training, research internship**

\* Opening september 2011



# BioMechanics & BioMaterials (BM)<sup>2</sup>

## Chairpersons

**S. Laporte**, PhD  
Arts et Métiers ParisTech

**L. Corté**, PhD  
Mines ParisTech

**Pr. F. Rannou**, MD, PhD  
Université Paris Descartes

BMBM@bme-paris.org

A part of this track is in the continuity of Arts et Métiers ParisTech « BIOST » master.

The BioMechanics & BioMaterials track (BM)<sup>2</sup> provides fundamental tools and in-depth knowledge on the biomedical applications of mechanics, materials science and related fields.

(BM)<sup>2</sup> education and training focus on recent and anticipated developments in biomechanics and biomaterials that hold promise for innovative solutions to major health problems and that respond to industrial challenges.

The lectures, team projects, case studies, and engineering and medical invited conferences by academic and industrial experts enable students to benefit from a stimulating and multidisciplinary environment.

This program provides scientists, engineers, and medical students with the wherewithal to face the numerous challenges of biomechanics and biomaterials R&D; how to apply their skills in order to solve specific biomedical problems, how to carry out innovative and fruitful research with the appropriate methods and ethical considerations, how to collaborate and interact in projects at the interfaces among mechanics, materials, and biomedical science.

A set of core teaching units provides a broad overview of basic and state-of-the-art knowledge of biomechanics and its methods, as well as of biomaterials. In-depth focus on major biomechanics issues and biomaterials research is developed in a series of six sub-tracks.

Each student chooses a sub-track and selects a set of at least four teaching units: three specific to the particular sub-track and one from the general master's program. A pedagogical commission of lecturers and researchers assists students and helps them to devise a personalized program consistent with their individual backgrounds and professional objectives.

**Core courses**  
(except subtrack CBM:  
U.E. 3.0, 3.1 and 3.2)

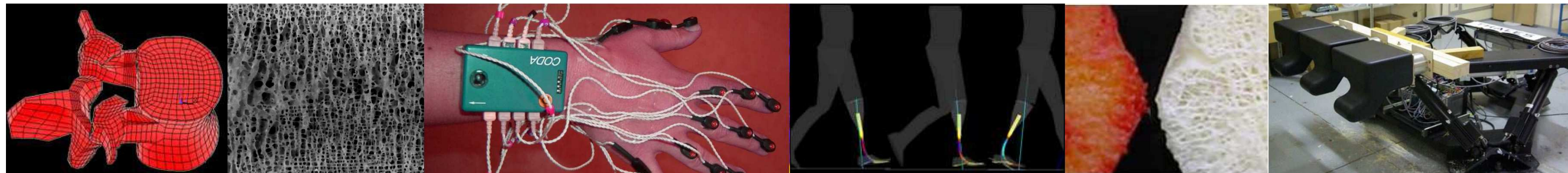
Third semester

<b>UE 3.0</b> – Seminars & conferences
<b>UE 3.1</b> – Interdisciplinary week
<b>UE 3.2</b> – Methodology & tutorial project
<b>UE 3.3</b> – Modeling & simulation for bio-mechanics
<b>UE 3.4</b> – Basics in cell and tissue biology
<b>UE 3.5</b> – Basics in biomaterial science

Fourth semester

<b>UE 4.0</b> – Ethical aspects of bioengineering
<b>UE 4.1</b> – Economical & industrial aspects
<b>UE 4.2</b> – Lab training, research internship

- Impact & Injury Mechanisms (I2M)
- Biomaterials & Biological Materials (B2M)
- MusculoSkeletal System (MS2)
- Clinical BioMechanics (CBM)
- Neuroengineering (NEC)
- Biofluid & the Cardiovascular System (BCS)



## Subtrack « Impact & Injury Mechanisms (I2M) »

### Contact

**Sebastien LAPORTE**  
Arts & Métiers ParisTech

I2M@bme-paris.org

### Subtrack courses

**UE 3.6a** - Accidentology & regulations

**UE 3.7a** - Impact mechanics & high velocities

**UE 3.8a** - Experimental methods for impact biomechanics

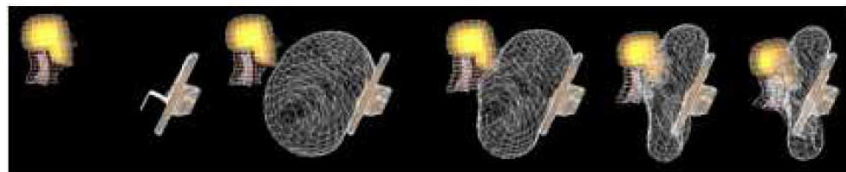
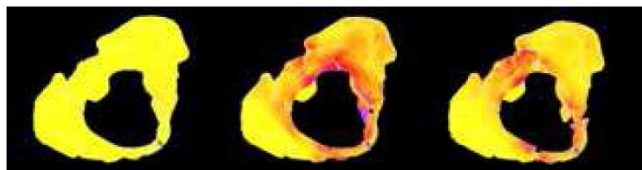
**UE 3.9a** - Traumatology, injury mechanisms & therapies

Road safety is a major socio-economic issue. The World Health Organization predicts that road accidents will be the third biggest killer worldwide by 2020.

The objective of the BME-Paris Master's track is to validate the dialogue and complementarity related to road safety by awarding an original diploma in this field at both the national and international level.

The aim of the I2M track is to widen and deepen the scientific bases of road safety, as well as its clinical considerations. I2M training is mainly directed toward human modeling of high-velocity loading, but also includes a broad range of multidisciplinary domains, leaning heavily on experimental and clinical data. I2M training is designed to confer a wide range of competencies, from fundamental scientific analysis to concrete knowledge of various aspects of the field, such as accidentology data, regulation, and ethics considerations.

The presence among the teaching staff of representatives from INRETS (French National Institute of Research on Transport and Safety), as well as from French automobile manufacturers (LABGIE Renault-Peugeot), provides concrete approaches to problems related to this theme.



## Subtrack « Biomaterials & Biological Materials (B2M) »

### Contact

**Pr. François RANNOU**  
Université Paris Descartes

**Laurent CORTE**  
Mines ParisTech

B2M@bme-paris.org

### Subtrack courses

**UE 3.6b** - Tissue engineering and implant design

**UE 3.7b** - Development, growth and repair of living tissues

**UE 3.8b** - Handling of proteins & bio-membranes

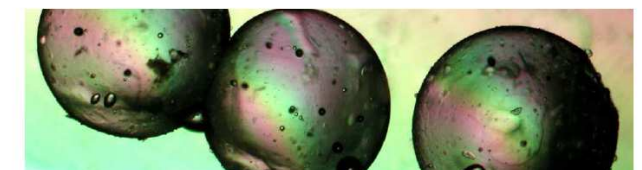
**UE 3.9b** - Biointerfaces

**UE 3.10b** - Engineering of bio-sourced polymers

**UE 3.11b** - Fundamentals of biotherapy

Recent progress in the understanding, characterization, and manipulation of biological materials has led to remarkable opportunities in the biomedical field, as well as in the biomaterials industry. Biomaterials research and development currently not only encompasses, but extends beyond the field of prosthetics design. Modelling and control of biological, bio-sourced, bio-compatible, and biomimetic materials are central to the development of numerous biomedical applications.

The Biomaterials and Biological Materials track provides students in-depth knowledge of the understanding and use of biomaterials, from nanoscale biomolecules, such as proteins, lipids, and bio-source polymers to macroscale prostheses and implants. B2M focuses on health-related applications ranging from implant and tissue engineering through the modelling and characterization of biological materials to material design for therapeutics.



## Subtrack « MusculoSkeletal System (MS2) »

### Contact

Pr. Wafa SKALLI  
Arts & Métiers ParisTech

MS2@bme-paris.org

### Subtrack courses

UE 3.6c – Non-linear aspects for the musculoskeletal modeling

UE 3.7c – Medical imaging & geometrical modeling

UE 3.8c – Muscular system modeling

UE 3.9c – Movement analysis & surgical navigation

UE 3.10c - Biomechanics & orthopaedics

UE 3.11c - Prosthesis: development, design & handicap

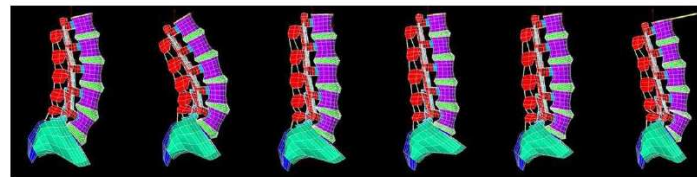
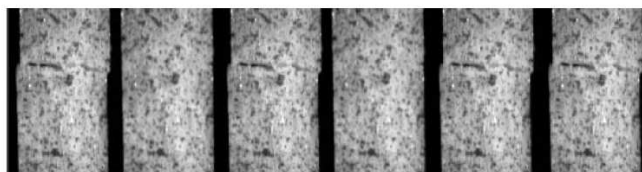
Biomechanical modeling is used in the analysis of musculoskeletal pathologies. The frequency and healthcare impact of these diseases are such that 2000-2010 has been named the “Bones and Joints Decade” by the UN and the WHO. Articular diseases account for half of all chronic pathologies observed after 65 years of age. The prevention of sports traumatism, as well as sports performance research, require the development of new methods in the effort to understand the behavior of the musculoskeletal system.

This subtrack will have a particular focus on methods for geometric and mechanical modelling of the musculoskeletal system: finite element approaches, direct and inverse dynamics in relation with gait analysis, modelling of the muscles and the neurocontrol activation system.

Experimental approaches and quantitative functional investigation from medical data are also key issues that will be addressed. Transversal links with the other BME tracks will be encouraged, since musculoskeletal modelling is related to bioimaging, mechanical properties biologic tissues and biomaterials, neuroengineering and biotherapy. In these related fields, light will be brought on specificities when considering the musculoskeletal system.

Example of research projects in this track:

- Experimental and finite element analysis of a disc prosthesis.
- Subject specific modelling of cerebral palsy gait for optimization of therapeutic strategy.
- Finite element modelling for osteoporosis fracture risk prediction.



## Subtrack « Clinical BioMechanics (CBM) »

### Contact

Pr. Wafa SKALLI  
Arts & Métiers ParisTech

Pr. Jean-Marc FERON  
Université Pierre & Marie Curie

CBM@bme-paris.org

### Subtrack courses

UE 3.6f – Statics

UE 3.7f – Kinematics

UE 3.8f – Strength of materials

UE 3.9f - Finite elements modeling

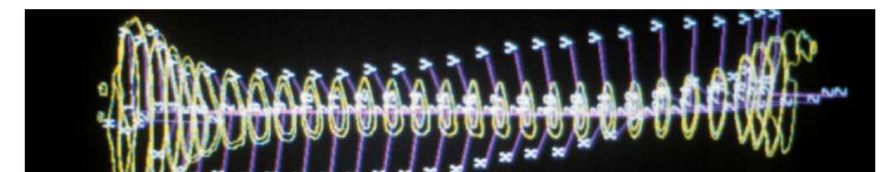
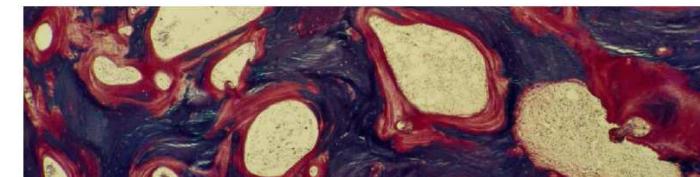
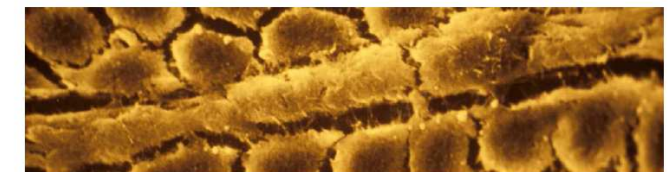
UE 3.10f - Kinematics of joints & gait analysis

UE 3.11f – Materials & structure behavior

Plus one additional course chosen from among courses of subtracks I2M, B2M, MS2, NEC & BCS.

The GBM track introduces BME students with life science backgrounds to engineering science tools and techniques, in order to provide them with a “language” that enables them to interact with students from engineering science backgrounds on interdisciplinary projects. The GBM track trains life-science students to understand the mechanisms of the human body in engineering terms, in view of specializing in biomechanics, the musculoskeletal system, cardiovascular and orthopedic medicine.

Since this program was introduced in France during the 1980s at Arts et Métiers – ParisTech, around 200 orthopedics surgeons have been trained there in clinical biomechanics.



## Subtrack « NeuroEngineering (NEC) »

### Contact

**Pierre-Paul VIDAL**  
Université Paris Descartes

NEC@bme-paris.org

### Subtrack courses

**UE 3.6e** - Brain-computer interfaces: motricity supplements

**UE 3.7e** - Brain-computer interfaces: sensory supplements

**UE 3.8e** - Brain-computer interfaces: detection & modulation of states of vigilance

**UE 3.9e** - Brain-computer interfaces: modeling & system design

**UE 3.10e** - Fundamentals of neurology & physiology

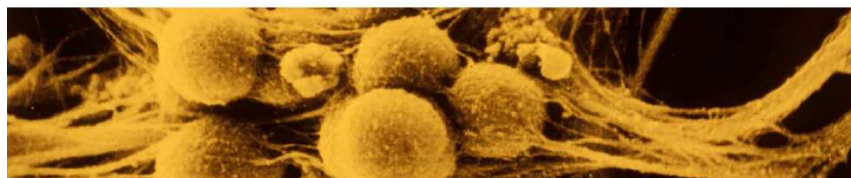
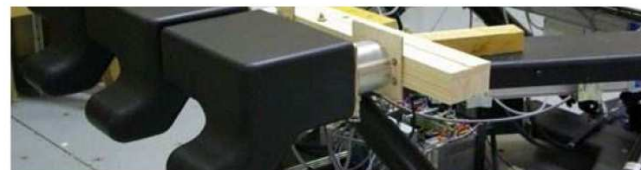
**UE 3.11e** - Fundamentals of technology & engineering

The goal of this track is not only to better understand the coding and processing of information in sensory and motor systems and to quantify sensorimotor transformations under normal conditions, but also how these are altered in pathological states and under extreme conditions, such as microgravity.

NEC brings together an ensemble of methods, ranging from computational neuroscience, molecular and cellular neurobiology, information theory, electronics, control systems, mathematical modeling, electrophysiology, biomaterials, to tissue engineering.

The first approach covered in the NEC track is *reverse engineering*, which uses computer modeling and data analysis tools to study the design principles of the nervous system. The second approach is *forward engineering*, which is used to investigate how neural models can effectively solve control tasks *in vivo*. Forward engineering is also concerned with how invasive and non-invasive neuroprosthetics and brain-computer Interfaces can be used to manipulate and enhance interactions between the nervous system and its input/output relationships for testing hybrid neural systems.

The NEC track trains students from life-science backgrounds (especially neuroscience and medicine) to work side-by-side with students from engineering backgrounds. This innovative mix of students with diverse backgrounds, approaches, and ideas do internships in laboratories working in areas that correspond to their particular needs; *i.e.*, a neuroscience laboratory for an engineer and an engineering laboratory for a neuroscientist. The NEC track develops a common language for neuroscientists, physicians, and engineers, allowing them all to pursue new collaborative projects and to reach beyond the limits of their original disciplines.



## Subtrack « Biofluid & the Cardiovascular System (BCS) »

### Contact

**Pr. Antoine LAFONT**  
Université Paris Descartes

BCS@bme-paris.org

### Subtrack courses

**UE 3.6d** - Study of biological flows

**UE 3.7d** - Cardiovascular system modeling

**UE 3.8d** - Tissues of the cardiovascular system

**UE 3.9d** - Biofluids & complex fluids in biology

**UE 3.10d** - Clinical aspects: stents, cardiac surgery, cardiovascular diseases

**UE 3.11d** - Fundamentals of biotherapy

The aim of the Biofluid and cardiovascular system track is to educate and train scientists, physicians, and engineers in the physical, biological, and clinical bases of the cardiovascular system. The objective of this track is to enable them to develop innovative applications in this field while employed in the implantable cardiovascular medical device industry. This rapidly growing sector needs people with double training in fundamental bioengineering and clinical skills.

BCS courses are taught by engineers, researchers, cardiologists, and cardiac surgeons familiar with therapeutic innovations in the cardiovascular domain.

The aim is to create a link between the clinical intuition and the bioengineering, in order to face new challenges in such areas as artery repair, cardiac valve pathologies, and treatment of cardiac insufficiency.





# Industrial BioEngineering (IBE)\*

Chairperson

T. Galopin, PhD  
ESPCI ParisTech

IBE@bme-paris.org

This speciality is shared with an existing bioengineering cursus hosted by ESPCI ParisTech and is the sole cursus in France with industrial aim in the field of bioengineering. It is made to give students the skills allowing them to deal with the main aspects of engineering in life and health science.

As the other specialities of the BME-Paris master program, it leaves a wide part to interdisciplinarity and is designed for both student from engineering schools, including agronomic schools, and from university (biologists, chemists, biochemists, physicists, pharmacists, doctors, etc...) having a robust initial formation in physics and/or chemistry.

The industrial approach of this speciality is conferred by the pedagogic organisation of lectures, given by professionals coming from research and development department of major industries. In addition, students have to be autonomous and are in charge of finding their end-cursus lab training, that must be made in an industrial R & D laboratory.

The Industrial BioEngineering (IBE) track features an interdisciplinary curriculum that is more specifically suited for students with an academic background in chemistry and physics. Courses include bioimaging, combinatorial chemistry (eg, the physical chemistry of colloids and polymers), analytical biochemistry, bioinformatics and statistics, computer modelization...

In addition to academic courses, the IBE track provides students with ten weeks of training at the ParisTech ESPCI laboratories, where, under the supervision of experienced researchers, they acquire the skills and experimental methods they need to develop an approach to a scientific problem of their choice and to carry out an original bioengineering project, harvesting and evaluating the results of their own work.

The interdisciplinary training and experience provided by IBE specialization affords opportunities in numerous professional fields: the pharmaceutical and cosmetics industry; genomics and post-genomics start-up firms; the medical device electronics industry (especially medical bioimaging); the chemical industry (biosensors); the agrofood-processing industry; biotechnologies; environmental chemistry... A notable characteristic of these industrial firms is their significant investment in research and development.

## Core courses

Third semester

UE 3.0 – Seminars and conferences
UE 3.1 – Interdisciplinary week
UE 3.2 – Biology refresher courses
UE 3.3 – Optical, acoustic & magnetic imaging
UE 3.4 – Physical chemistry of colloids & polymers
UE 3.5 – Chemistry for industrial bioengineering
UE 3.6 – Modelization: from molecule to behaviour
UE 3.7 – Bioinformatics & applied statistics
UE 3.8 – Microfluidics & tissue engineering

Fourth semester

UE 4.0 – Ethical aspects of bioengineering
UE 4.1 – From research to innovation
UE 4.2 – Tutored bioengineering project
UE 4.3 – Industrial training

\* Opening september 2011

