

Health Engineering

Health Engineering covers a broad range of disciplines, including medicine, life sciences, humanities, and various areas of engineering, including robotics, modeling and simulation. Sorbonne University's broad range of disciplines is uniquely suited to this growing sector.



IUIS: THE UNIVERSITY INSTITUTE FOR HEALTH ENGINEERING

Sorbonne University is developing a Health Engineering Institute (IUIS), drawing on all its considerable capabilities in engineering, medicine, technology and social sciences. The goal of IUIS is to coordinate and develop a greater scale of research, development, innovation and technology transfer, as well as educating transdisciplinary professionals in this increasingly important area.

With the laboratories in UTC* and UPMC's* Faculties of Engineering and Medicine, Sorbonne University is fully equipped to:

- Identify and develop applications to improve health and quality of life
- Develop and mobilize translational research
- Foster an ecosystem for the evaluation, transfer and implementation of technologies and services for well-being
- Educate future professionals

The scientific project is structured around four areas:

- Modeling and simulation of healthy and pathological subjects
- Design biomedical devices
- E-health, including home maintenance and telemedicine
- Processing and analysis of signal and image (multi-modality and interaction)

This scientific project includes an educational component that spans the bachelor's to the doctorate).

Biomechanics & Bioengineering (BMBI)

BMBI, located on the UTC campus, uses disciplines from engineering (mechanical, modeling, signal processing and imaging) and life sciences (biology, biochemistry, physiology) to study the biomechanical and biomedical problems.

The lab's multidisciplinary research is organized on two themes: the study of artificial organs and biomaterials, and the study of the musculo-skeletal system. The object is to understand the functioning and mechanisms of living systems at different scales: systems, tissues and organs.

This knowledge will lead to the understanding of diseases and the development of bioartificial organs, diagnostic tools and the assessment of the medical treatment of diseases.

The researchers work in four areas:

- Cells, biomaterials, bioreactors
- Interactions between fluids and biological structures
- Multi-scale mechanical characterization and modeling
- Neuromechanics & electrophysiological signals

Laboratory of Computational & Quantitative Biology (LCQB)

The LCQB is an interdisciplinary laboratory working at the interface between biology and quantitative sciences. It promotes the interaction of theoretical and experimental approaches in biology and fosters the definition of new experimental questions, data analysis and modeling of biological phenomena.

Its projects address questions on biological structures and processes through the gathering of experimental measures, the *in silico* generation of new biological data that remain inaccessible to experiments today (modeling of biological systems), the development of statistical methods for data analysis, and the conception of original algorithms to make predictions. The lab is supported by UPMC and the CNRS.*



The lab's research covers:

- Genome architecture and evolution: genome stability, mobility of genetic elements, lateral transfer, sharing, creation and loss of genes among strains and across species, gene essentiality, non-coding information in genomes, and speciation.
- Network architecture and evolution: structure and evolution of genetic networks among species, their ecological relevance in terms of adaptive and nonadaptive processes, genomic adaptability and network adjustments upon environmental changes.
- Protein evolution: mechanical properties, networks of coevolved amino acids in proteins, evolution and folding pathways, protein interaction, and speciation via divergent evolution of duplicated genes.

The LCQB has been awarded several major certifications, including:

- **Laboratory of Excellence:** in Bioinformatics, as one of 100 projects of excellence selected for government funding in the program *Investing for the Future*.
- Member of several European Research and Training networks and the EMBRC.

The LCQB also supports a Master's Program in Bio-informatics and Modeling.

Enzymatic & Cellular Engineering Laboratory (GEC)

The GEC Lab at UTC focuses on the study of biocatalysis and biorecognition at three levels of complexity—molecular, supramolecular and cellular. It also addresses the de novo creation of functions, materials and objects for applications in biotechnology. The scientific approach of GEC combines the understanding of the behavior of

natural biocatalysts and bioreceptor molecules in their complex environment, and the creation of new functions to explain the reality of living and produce biotechnological tools.

The laboratory's expertise in this domain enables new technological developments dedicated to the medical and industrial sectors. The research activities of GEC are organized in three themes:

Biocatalysis & Metabolic Alternatives in Plants studies lipid metabolism and metabolic engineering in plants, as well as the enzymatic transformation of materials from plant origins.

Membrane Biology teams research the structure and function of biological membranes and membrane proteins, on living cells and using biomimetic membrane models, using the tools of biophysics and nano-biotechnology.

Biomimicry, Molecular Recognition and Functional Nanomaterials works on molecularly imprinted polymers as antibody mimics, nanostructuring and nanocomposites, the genesis and characterization of diversity in biorecognition and biocatalysis, and on applications for example in biomedicine, bioanalysis and biosensors, and cosmetics;

Medical Computing & Knowledge Engineering Laboratory for e-Health (LIMICS)

LIMICS studies the challenges of treating health information in e-Health systems. The lab has two research areas. The first centers on medical research and the care of patients, by defining the applicable medical objectives for the decision support systems that are currently being developed. The second research area is developing methods and tools for knowledge modeling and knowledge representation in e-health.

This lab is the merger of established biomedical informatics and knowledge engineering teams. It includes Inserm* researchers and professor-researchers in medical informatics and computer science. The lab has 53 members, of which 26 are permanent and 10 are certified to supervise the 16 doctoral candidates.

* Inserm: National Institute of Health and Medical Research
** EMBRC: European Marine Biological Research Center

Sorbonne University is particularly adapted to leading the development of the important and growing field of Health Engineering.

LIMICS actively applies for research funding from both national and European organizations. The lab also supports master's and doctoral programs, and benefits from regular input from Sorbonne University health institutions and from national and international standardization bodies in health informatics. LIMICS research will lead to better use of electronic medical records to support patients, and to enable the synthesis, reuse and integration of data in semantic warehouses for research. Its research will also produce advances in the treatment of masses of large data and in the Semantic Web.

The Vision Institute

Established in the heart of the *Quinze-Vingts* National Eye Hospital, the Vision Institute is one of the largest research centers in Europe for eye diseases. Designed for gathering experts and encouraging exchanges, the Institute brings together researchers, clinicians and industrial partners in the fight against visual impairments. Locating these teams in the same building enables the sharing of ideas and skills, the emergence of new questions and facilitates the delicate process of translating fundamental discoveries into new treatments.

The Institute, co-supervised by Inserm, UPMC and the CNRS, has 17 research teams organized in four large departments: development; visual information processing; genetics of eye diseases and innovative therapeutic strategies. Alongside these teams, companies at the Institute develop vision research projects, such as drug discovery, imaging, surgery, and new technologies.

The latest advances in analysis, exploration and imaging are available to researchers and industrial partners on technological platforms: patch-clamp, multi-electrode array, genotyping, sequencing, high-throughput screening, phenotyping of small animal and non-human primates, and imaging (Brainbow, two-photon microscopy, confocal microscopy, and slide scanner: SLO, OCT, and adaptive optics). Two platforms, HomeLab and StreetLab, provide training, consulting and evaluation services to companies developing innovative products and services to improve autonomy, mobility and quality of life of visually impaired people.

* The See & Hear Foundation

The Institute's scientists work hand in hand with the clinicians of the Clinical Investigation Centre of the *Quinze-Vingts* hospital, which is dedicated exclusively to ophthalmology and also houses the National Reference Centre for Genetic Retinal Dystrophies. More than 50 studies (including phases I to III clinical trials, physiological and physio-pathological studies) are currently in progress on AMD, retinitis pigmentosa, diabetic retinopathy, retinal vein occlusions, artificial retina, glaucoma and high-resolution imagery of the retina.

FRENCH AND INTERNATIONAL RECOGNITION

The Vision Institute has been attributed many certifications, of which the most notable are:

- **Laboratory of Excellence:** "LIFESENCES: senses for a lifetime" is one of 100 projects of excellence selected for government funding in the program *Investing for the Future*. It is coordinated by the Vision Institute and managed by the *Voir et Entendre Foundation**
- The *CTRS/RTRS Fondation Voir et Entendre* certification, in recognition of its promotion of research programs on vision and audition diseases, alongside Inserm, UPMC, the *Quinze-Vingts* hospital, the Pasteur Institute and the Federation of the blind and visually handicapped of France (FAF).

The CNRS Communication Sciences Institute (ISCC)

The ISCC conducts research in the interaction between science, technologies and society. The ISCC also hosts and federates research teams.

In particular, the Institute carries out research in healthcare engineering, primarily through its Connected Health and Human Enhancement pole, which studies sociological, philosophical and ethical implications of these technologies. International symposia and other collaborations are in progress, in particular with the University Institute of Healthcare Engineering (UISI, see cover page) to foster research at the interface between health, engineering and human sciences.

The ISCC partners with more than 1,000 researchers in 250 laboratories on ISCC research themes. The Institute hosts doctoral and post-doctoral students, giving access to researchers and the scientific resources in the digital library as well as many research seminars.

IUIS Co-managers: Yves Berthaud, Cécile Legallais and Pierre Mozer | **BMBI:** www.utc.fr/bmbio | **LCQB:** www.lcqb.upmc.fr | **GEC:** www.utc.fr/umr6022.f | **LIMICS:** www.limics.fr | **The Vision Institute:** www.institut-vision.org | **ISCC:** www.iscc.cnrs.fr