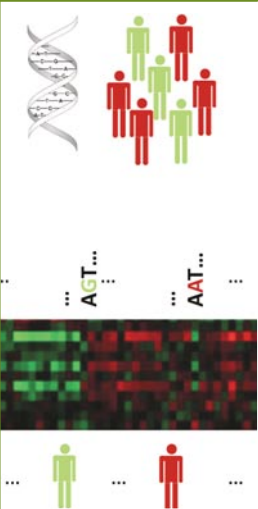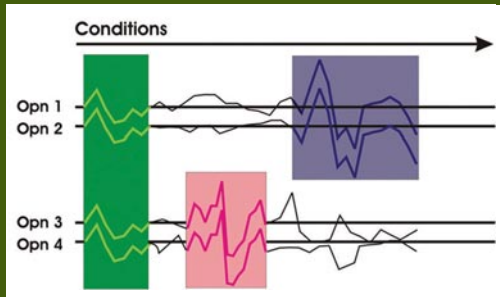# KU LEUVEN

Master of Science in Bioinformatics

Faculty of Bioscience Engineering
Faculty of Engineering Science
Faculty of Medicine
Faculty of Science

KU Leuven. Inspiring the outstanding.

Bioinformatics

Molecular biology is in the midst of a technological revolution. 60 years ago, scientists elucidated the structure of DNA. 15 years ago, they successfully sequenced the human genome after a massive international effort. Today, we can sequence a human genome for €1,000 – and generate terabytes of data in the process. We can also create mass spectroscopy images of brain tumours, study the genetic diversity of fish populations, identify thousands of protein-protein interactions in plants, reconstruct the metabolic network of industrial yeast strains, sequence all the microorganisms of the gut flora of a patient, and many more technological achievements that were hard to imagine even a decade ago. The impact on most areas of biology, ecology, biotechnology, genetics, pharmacy, or medicine is staggering.

As a result, much of biology has become both an experimental science and an information science, often called systems biology. Organising and exchanging massive amounts of biological data and knowledge, designing complex experiments, statistically analysing and data mining results, creating mathematical models of complex biological systems, and integrating data to make predictions to direct new experiments are at the core of systems biology. Biology has grown from a science in which each piece of data had to be painstakingly produced in the lab to a 'big data' science in which much of the work takes place before and after the actual experiment. This requires a set of skills beyond that of classical training in biology, biotechnology, or biomedical sciences, but also beyond that of classical training in computer science, engineering, or statistics.

Bioinformaticians, also known as computational biologists, are highly interdisciplinary data scientists who bring together molecular biology, information technology, and mathematical engineering. This interdisciplinarity is essential to (1) understand biological and biomedical problems and reformulate them as data analysis problems, (2) create efficient and scalable infrastructures to access, store, exchange, and process data and knowledge, and (3) devise powerful statistical analysis, data mining, machine learning, and mathematical modelling strategies to understand those vast troves of data.

Because of the challenges of bringing all this complementary expertise together, the MSc in Bioinformatics is an interfaculty programme jointly organised by the Faculty of Bioscience Engineering, the Faculty of Engineering Science, the Faculty of Science and the Faculty of Medicine at KU Leuven.

The MSc programme

The expertise of the bioinformatician consists in the ability to design, manage, analyse, and interpret data from high-throughput molecular biological experiments characterised by a high complexity and dimensionality and to independently develop new methods for solving bioinformatics challenges. The objective of the programme is to train qualified bioinformaticians who will be able to integrate biological knowledge and insight with the knowledge and understanding of important principles of information technology, mathematics, and statistical techniques.

This two-year programme focuses on acquiring (1) broad and integrated knowledge of molecular biology, information technology, and data science, (2) expert knowledge in the core areas of bioinformatics, (3) application-oriented programming skills, and (4) interdisciplinary engineering skills. The 120-ECTS programme consists of (1) a reorientation package (one semester) during which students expand their initial background to prepare for the core bioinformatics courses, (2) a common package (two semesters) focused on core bioinformatics courses and bioinformatics-oriented information technology training, and (3) a thesis. For students accepted into the relevant major, the programme can lead to the official Belgian title of *bio-ingenieur* or *burgerlijk ingenieur*. The programme attracts students from all over the world, which adds a valuable intercultural element to the programme experience.

Discover KU Leuven

Situated in Belgium, in the heart of Western Europe, KU Leuven has been a centre of learning for nearly six centuries. Today, it is Belgium's largest and highest-ranked university and, founded in 1425, one of the oldest and most renowned universities in Europe. As a leading European research university and co-founder of the League of European Research Universities, KU Leuven offers a wide variety of international master's programmes, all supported by high-quality, innovative, interdisciplinary research.

Since its founding, KU Leuven has been based in the city that shares its name. Leuven is a pleasant, safe and bustling student town, where centuries-rich history meets cutting-edge science. The university also offers degree programmes at campuses in 11 Belgian cities, including Brussels, Ghent and Antwerp.

Admission requirements

Holders of the following degrees are granted direct admission to the programme for the respective major:

Major Bioscience Engineering (bio-ingenieur):
- Bachelor (of Science) in de bio-ingenieurswetenschappen

Major Engineering Science (burgerlijk ingenieur):
- Bachelor (of Science) in de ingenieurswetenschappen: hoofd- of nevenrichting computerwetenschappen of nevenrichting technologie van de levende systemen

Major Science:
- Bachelor (of Science) in de geneeskunde
- Bachelor (of Science) in de biomedische wetenschappen
- Bachelor (of Science) in de biochemie en de biotechnologie
- Bachelor (of Science) in de biologie
- Bachelor (of Science) in de chemie, minor: biochemie en biotechnologie
- Bachelor (of Science) in de fysica, minor: bio-chemische wetenschappen / sterrenkunde en informatica
- Bachelor (of Science) in de informatica
- Bachelor (of Science) in de wiskunde, minor: IT

For holders of other bachelor's or master's degree from KU Leuven and for all holders of bachelor's or master's degrees from outside KU Leuven, admission decisions are based upon evaluation of a complete application file. Registration for the Bioscience Engineering or Engineering Science major has to be approved by the academic board.

With the exception of native English speakers, holders of accredited degrees taught in English, or holders of a bachelor's or master's degree from KU Leuven, students should present results of a test of English proficiency (TOEFL/IELTS) at or exceeding the following scores: TOEFL (Computer-based test 213 pt., Internet-based test 79 - 80 pt., Paper-based test 550 pt.) or IELTS (6.5 - 7 pt.).

Programme

- **A reorientation package** (min. 27 ECTS). This package includes strengthening courses to equip you for the basic requirements of the common package. The programme committee of the MSc programme will tailor the content of the reorientation package to each individual student based on his or her educational background.
- **A common package**. The common package builds upon the elementary knowledge and skills students have gained in their previous studies and in the reorientation package and integrates these into various bioinformatics courses. All students complete this package in its entirety.
- **A major** (equivalent to one semester, to be started at the beginning of the second year). This specialised package comprises an original research task in an academic or company setting, guided by a supervisor. It culminates in the public defence of an MSc thesis.

MASTER OF SCIENCE IN BIOINFORMATICS	120 ECTS
COURSES	ECTS
REORIENTATION PACKAGE	**min. 27**
Reorientation Biology	
• Basics of Biological Chemistry	4
• Basic Concepts of Cell Biology	5
• Structure, Synthesis and Cellular Function of Macromolecules	3
• Genetics, Genetic Nomenclature and Genetic Evolution Mechanisms	5
• Gene and Genome Technology	5
Reorientation Statistics	
• Univariate Data and Modelling	5
Reorientation Mathematics	
• Linear Algebra	7
• Calculus	6
Reorientation Information Technology	
• Basic Programming	4
• Object Oriented Programming	4
• Database Management	6
Reorientation Package: Optional Courses	

Depending on his or her background, the student selects courses totalling up to 27 ECTS from the reorientation packages, so as to achieve mastery of all areas of the reorientation package after completion of the selected courses. The suggested package is presented to the standing educational committee for approval. Proficiency in all areas of the reorientation package is necessary for successful completion of the rest of the programme.

COMMON PACKAGE	**64**
Biology Module	
• Molecular Interactions: Theories and Methods	4
• Bio-Molecular Model Building	5
• Model Organisms	5
Statistics Module	
• Applied Multivariate Statistical Analysis	5
• Statistical Methods for Bioinformatics	5
• Dynamical Systems	4
• Support Vector Machines: Methods and Applications	4
• Machine Learning and Inductive Inference	4
Bioinformatics Module	
• Practical Computing for Bioinformatics	3
• Omics Techniques and Data Analysis	4
• Management of Large-Scale Omics Data	4
• Bayesian Modelling for Biological Data Analysis	4
• Integrated Bioinformatics Project	5
• Comparative and Regulatory Genomics	4
• Evolutionary and Quantitative Genetics	4

COURSES	ECTS
MAJOR	
Science	
• MSc Thesis: Science	
Bioscience Engineering	
• MSc Thesis: Bioscience Engineering	
Engineering	
• MSc Thesis: Engineering	

For detailed descriptions of this programme's courses and for the course timetable, please consult www.kuleuven.be/ma/mbinfel

I am currently a postdoctoral scholar in computational biology at Stanford University. My research is in the domain of statistical computing and bioinformatics, focused heavily on applications in cancer genomics. The ultimate goal of my research is to translate a deeper understanding of biology into novel disease therapies. To enable my research to directly benefit patients through drug discovery and development, I recently joined a pharmaceutical research collaboration at Stanford as a bioinformatics scientist. With my interdisciplinary background and enthusiasm, I look forward to contributing to new cures for cancer.

(A Chinese graduate with a background in statistics and bioinformatics and currently working as a postdoctoral fellow at the Center for Cancer Systems Biology of Stanford University)
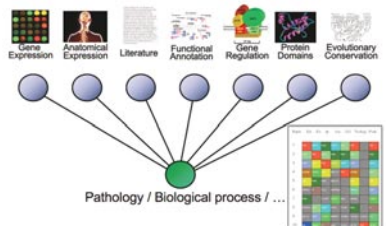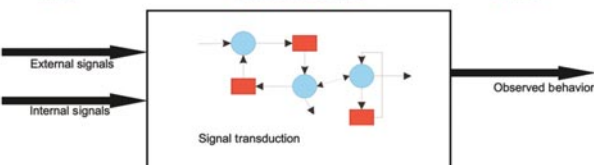
Studying abroad

All students are given the opportunity to conduct part of their MSc thesis research at a partner institution or organisation abroad. In addition, European residents may undertake their MSc thesis research at a European university within the framework of the Erasmus programme.

⤷ **www.biw.kuleuven.be/english/FutureStudents/graduate.aspx**

Career prospects

Many bioinformaticians find careers in the life sciences in the broadest sense: the pharmaceutical or biotechnology industry, high-tech start-ups, hospitals, public sector organisations (e.g. regulatory, healthcare), etc. Also, the expanding need for bioinformatics in biological and biomedical research ensures a large variety of job opportunities in fundamental and applied research. Additionally, over half of the graduates decide to pursue a PhD.

Bioinformaticians are distinguished by a broad training as data scientist, and this skillset has relevance beyond bioinformatics itself. As much of science, engineering, and industrial processes become increasingly driven by big data, professionals with the technical skills to handle vast amounts of complex and messy data and the strong interdisciplinary skills needed to communicate with experts from diverging backgrounds are becoming increasingly sought-after in many areas of industry. Many graduates thus also find positions in the many sectors of information technology.

At Cartagenia, we work on a daily basis with diagnostic genetics labs that rely on clinical informatics tools to make sense of the vast amounts of data resulting from routine genetic testing. As one of the scientific founders, I have witnessed from the onset how important it is to translate complex bioinformatics methods into everyday tools that work in the hands of laboratory technicians, directors, and clinical geneticists. The MSc in Bioinformatics at Leuven has been essential to learning and speaking the language of "both sides" – translating the challenges on both the biomedical and clinical sides into statistical and informatics tools, and building tools that solve them.

(A Belgian graduate with a background in computer science, cofounder and Marketing Director of Cartagenia, a spin-off of KU Leuven)

Learn more

www.kuleuven.be/ma/mbinfel

General information
www.kuleuven.be/english
www.kuleuven.be/internationalprogrammes
www.kuleuven.be/admissions
www.kuleuven.be/tuitionfees

Publications
www.masterskuleuven.be/publications

KU Leuven
Faculty of Bioscience Engineering
tel. + 32 16 37 95 64
International.MSc.Programmes@biw.kuleuven.be
www.biw.kuleuven.be/eng

www.fb.com/LeuvenUniversity

MEMBER OF

ASSOCIATIE
KU LEUVEN

v.u.: Isabelle Van Geet, Oude Markt 13, 3000 Leuven