Curriculum 2017-2018

Curriculum for Academic Year 2017-2018

Degree structure

Master of Science (Technology) degree is 120 ECTS credits. Master’s Programme in Life Science Technologies consists of major studies (60 – 65 ECTS), elective studies (25 - 30 ECTS), and master’s thesis (30 ECTS). Programme includes 15 ECTS of common studies for all students. Common studies are included in the major studies.

Master's Programme in Life Science Technologies offers a multidisciplinary curriculum focusing on important aspects of current and emerging technologies for life sciences, covering fields such as biological data analysis and modeling, advanced biomaterials and bioelectronics, biomedical engineering and neuroscience. The programme draws on fundamental and applied knowledge on these fields and is closely linked to research conducted in the participating Schools and Departments.

To prepare the graduates for their future work with large and often complex systems, the programme includes several practical project works in groups which provide skills for solving multifaceted and ill-defined problems similar to those faced in the actual professional life. These projects typically include experimental and practical components as well as fundamental theoretical aspects.

The programme also gives the student a comprehensive foundation for doctoral studies. The Bioinformatics and Complex Systems majors host a Doctoral track with a selective student intake.

Majors 2017-2018

Master's Programme in Life Science Technologies offers six majors for specializing in Bioinformatics, Biomedical Engineering, Biosensing and Biolectronics, Biosystems and Biomaterials Engineering, Complex Systems or Human Neuroscience and Technology.

Typically, a major consists of compulsory courses and of optional courses. 15 credits of compulsory courses are common to all majors.

Bioinformatics 2017-2018

Professor in charge: Harri Lähdesmäki

Extent: 60 credits

Abbreviation: BIOINFO

Code: SCI3058

Objectives

The Bioinformatics major in the Life Science Technologies programme is designed to give a strong competence in bioinformatics and computational systems biology. The Bioinformatics major provides robust background in probabilistic modeling, machine learning and data science to understand the methodological basis of the commonly used bioinformatics and computational biology methods. The Bioinformatics major also gives skills and tools to develop new computational methods and models and to apply them to real world biomolecular data. Computer practicals are part of most courses ensuring understanding of both theory and practice of the methods. Biological background or statistical data analysis expertise can be further broadened with an elective minor.

State-of-the-art methods for analyzing next-generation sequencing, microarray and other 'omics data as well as biological networks are part of the curriculum. Examples of research questions studied include predicting drug-target interactions, reconstructing biological networks, finding associations between genotypes and diseases, and modelling dynamical behavior of complex biological pathways.

Content and structure

For the major (60 ECTS credits) the students have to take the common courses of the Life Science Technologies programme (15 cr), mandatory major subject courses (35 cr) and choose optional courses (10 cr) from the course list given below. To complete the degree, students take language studies (3 cr) and elective courses (minimum 27 cr). For elective courses, a minor subject, an international mobility period or an internship is recommended.

Code	Course	Credits	Period/Year
Compulsory courses of the programme (15 credits):			
MS-E2115	Experimental and Statistical Methods in Biological Sciences	5	I-II/1
JOIN-E3000	Life Science Technologies Project Course	10	III-V/1
Compulsory courses of the major (35 credits):			
CHEM- E8120	Cell Biology**	5	II/1
CS-E5860	Computational Genomics	5	I/1
CS-E5870	High-throughput Bioinformatics	5	II/1
CS-E5880	Modelling Biological Networks	5	III/1
CS-E5890	Statistical Genetics and Personalised Medicine	5	IV-V/1
CS-E3210	Machine Learning: Basic Principles	5	I/1
CS-E4880	Machine Learning in Bioinformatics	5	I-II/2
Optional courses of the major (choose 10 credits):			
CS-E4840	Information Visualization	5	IV/1
CS-E4830	Kernel Methods in Machine Learning	5	I-II/2
CS-E4820	Machine Learning: Advanced Probabilistic Methods	5	III-IV/1
CS-E3190	Principles of Algorithmic Techniques	5	I-II/1
CS-E5710	Bayesian Data Analysis	5	I-II/I or 2
CHEM-E8125	Synthetic Biology	5	IV-V/1
CHEM-E3170	Systems Biology	5	IV-V/1

**Students with no or little background in biology can replace obligatory course CHEM-E8120 Cell Biology with course CHEM-C2300 Cell and Molecular Biology. The language of instruction of CHEM-C2300 is Finnish, but it can be taken in English as a self-study course. The change must be agreed with the professor of the major.

Recommendations for elective studies for bioinformatics

For the elective studies to accompany the bioinformatics major, it is recommended to take a minor subject or an international mobility period or an internship. The autumn period of second year is the recommended time period for elective studies.

Recommended minors

The following minors given in Aalto University are recommended:

Life Science Technologies programme minors:

- Biomedical engineering
- Biosensing and -electronics
- Complex systems
- Human Neuroscience and -technology

Computer, Communications, and Information Science programme minors:

- Machine Learning and Data Mining

In addition, University of Helsinki (www.helsinki.fi) offers courses suitable for elective studies in

- Algorithmic bioinformatics
- Molecular biosciences
- Biomedicine

Courses offered by University of Helsinki can be taken through the Flexible Study Rights (JOO) agreement (www.joopas.fi).

Recommendations for international mobility

An international mobility period of approximately one semester is recommended. The suitable timing for mobility is Autumn period of the second study year.

Biomedical Engineering 2017-2018

Professor in charge: Ari Koskelainen

Extent: 65 credits

Abbreviation: BME

Code: SCI3059

Objectives

Biomedical Engineering builds on a solid basis of physics and technology to characterize, monitor, image and influence biological systems. This major introduces the student to the physics of biological systems in order to efficiently measure, image, and model such systems. In addition, this major provides the basic knowledge and skills for developing novel engineering solutions for diagnostic and treatment needs in health care. The major offers excellent foundations for pursuing a career in medical technology industry or in academia.

Content and structure

For the major (65 ECTS credits) the students have to take the common courses of the Life Science Technologies programme (15 cr), mandatory major subject courses (25 cr) and choose optional courses (25 cr) from the course list given below. To complete the degree, students take elective courses (minimum 25 cr). For elective courses, a minor subject or an international mobility period is recommended.

Code	Course	Credits	Period/Year
Compulsory common courses of the programme (15 credits):			
MS-E2115	Experimental and Statistical Methods in Biological Sciences	5	I-II/1
JOIN-E3000	Life Science Technologies Project Course	10	III-V/1
compulsory courses of the major (25 credits):			
NBE-E4100	Molecular Biophysics	5	III-V/1
NBE-E4050	Signal Processing in Biomedical Engineering	5	I-II/1
NBE-E4000	Principles of Biomedical Imaging	5	I-II/1
NBE-E4510	Special Assignment in Biomedical Engineering	10	I-V/1, summer
optional courses of the major (choose 25 credits):			
NBE-E4120	Cellular Electrophysiology	5	I-II E *
NBE-E4140	Neurophysics	5	IV-V E*
NBE-E4130	Information Processing in Neural Circuits	5	III-V O**
NBE-E4060	Bioelectromagnetism: Fundamentals, Modelling and Application	5	IV-V, O**
NBE-E4020	Medical Imaging	5	III-IV E*
NBE-E4210	Structure and Operation of the Human Brain	5	I-II/1 or 2
NBE-E4010	Medical Image Analysis	5	I-II O**
NBE-E4045	Functional Brain Imaging	5	I-II/2
NBE-E4300	Medical Device Innovation	5	III-V E*

*E = lectured in even years

** O = lectured in odd years

Recommendations for elective studies for Biomedical Engineering

For the elective studies to accompany the biomedical engineering major, it is recommended to take a minor subject, an international mobility period or an internship. The Autumn period of second year is the recommended time period for the international mobility.

Recommended minors

The following minors given in Aalto University are recommended:

Life Science Technologies programme minors:

- Bioinformatics
- Biosensing and -electronics
- Biosystems and -materials
- Complex Systems
- Human Neuroscience and -technology

Recommendations for international mobility

An international mobility period of approximately one semester is recommended. The suitable timing for mobility is autumn period of the second study year.

Biosensing and Bioelectronics 2017-2018

Professor in charge: Tomi Laurila

Professors: Mervi Paulasto-Kröckel, Ilkka Tittonen, Raimo Sepponen, Simo Särkkä, Ilkka Laakso

Extent: 60 credits

Abbreviation: -

Code: ELEC3045

Objectives

The target is to educate engineering experts who have versatile comprehension of biosensors and other electronic applications. To accomplish this the student is introduced to nanoscale phenomena, microfabrication techniques, biomaterials science, biochemical recognition of biomolecules, physical transducers, sensor technologies and to good extent to clinical equipment like medical imaging. The tools needed in the development of innovations in the field of biosensors and bioelectronics are provided and the students are strongly encouraged to commercialize their own ideas.

Content and structure

This major combines studies both in the theory and practice needed to design, develop, fabricate and characterize biosensors, biomedical devices and medical instrumentations. Hands on experience is gained to understand the biocompatibility of both organic and inorganic materials used in electronics as well as the interactions between low frequency electromagnetic fields and living tissue and in special applications these interactions even with single cells and biomolecules.

code	course	credits	period/year
Mandatory common courses of the programme (15 credits):			
MS-E2115	Experimental and Statistical Methods in Biological Sciences	5	I/1
JOIN-E3000	Life Science Technologies Project Course	10	III-V/1
Mandatory courses of the major (20 credits):			
ELEC-E8728	Tissue-foreign Body Interaction	5	I-II
ELEC-E8726	Biosensing	5	III-IV/1
ELEC-E3260	Biomolecules	5	III /1
ELEC-E8734	Biomedical Instrumentation	5	II/1
Optional courses (25 credits):			
ELEC-E0200	Master's Thesis Process	0	II
CHEM-E5115	Microfabrication	5	III-IV
CHEM-E8135	Microfluidics and BioMEMS	5	III-IV/1
ELEC-D8723	Laboratory Course of Biomedical Engineering	5	IV-V/1
ELEC-E3151	Mathematical Computing	5-7	I-II
ELEC-E3220	Semiconductor Devices	5	III/1
ELEC-E3230	Nanotechnology	5	IV
ELEC-E8115	Micro- and nanorobotics	5	III-IV
ELEC-E8724	Biomaterials Science	5	I-II
ELEC-E8725	Methods of Bioadaptive Technology	5	I-II
ELEC-E8735	NMR - Basics	5	III/1
ELEC-E8736	Basics of MRI	5	III-IV/1
ELEC-E8737	Instrumentation of MRI	5	I
ELEC-E8738	Application of MRI	5	II
NBE-E4020	Medical Imaging	5	III-IV/1

Biosystems and Biomaterials Engineering 2017-2018

Professor in charge: Alexander Frey

Extent: 60 credits

Code: CHEM3028

Objectives

The major in Biosystems and Biomaterials Engineering gives graduates cutting edge scientific knowledge and skills enabling the students to integrate into the international life science technologies job market or to pursue doctoral studies in specialist fields. Graduates obtain a strong multidisciplinary knowledge of biological sciences and chemistry at the interface with technology and the ability to apply this knowledge in the fields of applied research, development, translational research and production, both in a research and business environment. The major is strongly research driven and is tightly linked to research activities related to the fields of biotechnology, organic chemistry, and biomaterials science at the School of Chemical Engineering. Employment sectors for graduates are within the pharmaceutical and medical technology industries within the broad context of engineering combined with chemistry and biotechnology.

Graduates in Biosystems and -materials major receive a broad training and in-depth knowledge, combined with practical experience. The major provides a solid understanding of biological phenomena, biomaterials and small organic molecules important to the field of Life science. At the core of the teaching are the understanding of molecular and cellular level phenomena, reprogramming of cells, molecular design and characterization of small pharmaceutically active molecules, and the synthesis and characterization of biomaterials. Specialization during the major allows acquiring in depth understanding in one of the selected fields or studying at the interface of the different fields.

Content and structure

The core contents of the major are based on a sound understanding of cellular systems (cell and molecular biology, biophysics, systems biology) and their reprogramming (synthetic biology), organic chemistry in the context of medicinal and natural products chemistry and the synthesis and characterization of materials and their applications in medicine (scaffolds, implants, drug release). The core contents focus on:

Structure and function of biomolecules in pro- and eukaryotic cells with respect to major metabolic pathways, cell energetics, physiology and regulatory pathways at the molecular level and interactions of biological molecules. Enzyme structure and function, enzyme catalysis and thermodynamics of biological systems.

Cellular physiology and its adaptation to different stimuli from the molecular to cellular level using transcriptomics, proteomics, metabolomics including modeling of complex systems.

Engineering of cellular systems including tissue engineering, stem cells and use of genetic engineering and synthetic biology for programming of cellular circuits, pathways or designing of bio-based materials, regulatory requirements and principles of Good Manufacturing Practice (GMP)

Synthesis, purification, characterization and application of synthetic and biopolymers. Polymer processing and engineering using chemistry and enzymes.

Colloid and surface science of biological materials, surfaces of materials as an interface to biology, interactions of inert and bioactive compounds (scaffolds, implants, wound dressing, etc) with biological systems

Pharmacologically active compounds derived from small molecules and natural biomacromolecules from the viewpoint of molecular interactions. Drug classes, based on both disease types and chemical structural classes, are discussed.

Use of mass spectrometry (MS), infrared spectroscopy (IR) and nuclear magnetic resonance spectroscopy (NMR) in the structural determination and identification of organic compounds

The core contents also include ethics of the profession and codes of conduct, organizing personal and teamwork and working part of a team, delegating and taking responsibility, effective communication of scientific knowledge to a forum of peers and experts and to the general public, conveying the key role of technology, engineering and science in promoting health and welfare.

The major is formed of compulsory studies of 40 cr and elective specialization courses of 20 cr in total. The compulsory studies include 15 cr studies that are common for all students in Master's Programme in Life Science Technologies.

code	course	credits	period/year
compulsory common courses of the programme (15 credits):			
MS-E2115	Experimental and Statistical Methods in Biological Sciences	5	1/1
JOIN-E3000	Life Science Technologies Project Course	10	III-V/1
compulsory courses of the major (25 credits):			
CHEM-E8100	Organic Structural Analysis	5	I/1
CHEM-E8110	Laboratory Course in Biosystems and Biomaterials Eng.	5	I-II/1
CHEM-E8120	Cell Biology	5	II/1
CHEM-E8130	Medicinal Chemistry	5	II/1
CHEM-E3120	Microbiology	5	I/1
optional courses of the major (choose 20 credits):			

CHEM-E8105	Enzymatic and Biomimetic Catalysis	5	IV/1
CHEM-E8115	Cell factory	5	III/1
CHEM-E8125	Synthetic biology	5	IV-V/1
CHEM-E8135	Microfluides and BioMEMS	5	III-IV/1
CHEM-E2100	Polymer Synthesis	5	I/2
CHEM-E2130	Polymer Properties	5	II/2
CHEM-E2150	Interfacial Phenomena in Biobased Systems	5	III-IV/1
CHEM-E2155	Biopolymers	5	III-IV/1
CHEM-E3150	Biophysical chemistry	5	III/1
CHEM-E3170	Systems biology	5	IV-V/1
CHEM-E3225	Cell- and Tissue Engineering	5	III/1
CHEM-E4150	Reactivity in Organic Chemistry	5	II/1
CHEM-E4195	Selectivity in Organic Synthesis	5	IV/1
CHEM-E4295	Asymmetric Synthesis of Natural Products	5	I/2
CHEM-E5135	Biomimetic Materials and Technologies	5	IV-V/1 or 2

Recommendations for elective studies

For the elective studies to accompany the major, it is recommended to take a minor subject.

The following minors given in Aalto University are recommended:

Life Science Technologies programme minors:

- Bioinformatics
- Biosensing and Bioelectronics
- Complex Systems
- Human Neuroscience and Technology
- Biomedical engineering

Suitable elective courses can be found from the list of elective specialization courses and selected courses from Bioinformatics or other majors in Life Science Technologies program.

Courses offered by University of Helsinki can be taken through the Flexible Study Rights (JOO) agreement (www.joopas.fi).

Complex Systems 2017-2018

Professor in charge: Professor Jari Saramäki

Extent: 60 credits

Abbreviation: CS

Code: SCI3060

Objectives

The aim is to give the students a strong computational and theoretical background for understanding complex systems, from the human brain to a diversity of biological and social systems. The major has been structured such that the student can choose which areas to emphasize (e.g. neuroscience, theory of complex systems, machine learning). After completing their studies, the students have the necessary skills for interdisciplinary scientific careers, or, e.g. for data scientist positions in the industry.

Content and structure

The major has been structured to allow for flexibility, and the student may emphasize chosen areas of interest. In addition to courses common to all Life Science Technologies masters, the major has four modules: 1) Measuring and interpreting data, 2) Advanced statistics and machine learning, 3) Systems and Modeling, and 4) Application areas. The student must pick at least one course from each module; the student is free to choose the rest of the courses freely from all modules.

Descriptions of the modules:

1. Measuring and interpreting data: courses for dealing with experimental data, its analysis, and visualization.

2. Advanced statistics and machine learning: Bayesian statistics and methods, basic principles of machine learning.

3. Network and systems: network science, chaos theory, non-equilibrium statistical mechanics, mathematical modeling.

Application areas: courses in all other Life Science Technologies majors.

Code	Course	Credits	Period/Year
Compulsory common courses of the programme (15 credits):			
MS-E2115	Experimental and Statistical Methods in Biological Sciences	5	I-II/1
JOIN-E3000	Life Science Technologies Project Course	10	III-V/1
Compulsory courses of the major (45 credits). Pick at least one course from each four modules:			
1 Measuring and intepreting data			
CS-E4840	Information Visualization	5	IV/1
CS-E5700	Hands-on Network Analysis	5	IV-V/1
MS-E2112	Multivariate statistical analysis	5	III-IV/1
2 Advanced statistics and machine learning			
CS-E5710	Bayesian Data Analysis	5	I-II/1
CS-E5720	Work Course on Bayesian Analysis	2	III-V/1
CS-E3210	Machine Learning: Basic Principles	5	I/2
CS-E4600	Algorithmic Methods of Data Mining	5	I/1 or 2
CS-E4890	Deep Learning	5	II/2
CS-E4070	Special Course in Machine Learning and Data Science	1-10	year 2
3 Networks and systems			
CS-E5740	Complex Networks	5	I-II/1
CS-E5745	Mathematical Methods for Network Science	5	III/1 or 2
CS-E5880	Modeling Biological Networks	5-7	III/1
CS-E5790	Computational Science	5	I-II/1
CS-E5755	Nonlinear Dynamics and Chaos	5	III-IV/I or 2
CS-E5780	Special Assignment in Complex Systems	5-10	year 2
CS-E5770	Special Course in Complex Systems	3-6	1 or 2

4 Application areas
Pick any course from the other Life Science Technologies majors.

Recommendations for elective studies

In their elective studies, the students are encouraged to take courses from other majors of the LifeTech programme, according to their interests. Courses in the field of information and computer science are also recommended. Also internship is recommended in elective studies.

Human Neuroscience and Technology 2017-2018

Professor in charge: Lauri Parkkonen

Extent: 65 credits

Abbreviation: NEURO

Code: SCI3601

Objectives

The aim is to give the students a strong background for understanding structure and function of the human brain, theoretical and practical knowledge on brain research methods and other neurotechnologies. After completing their studies, the students have an excellent background for a career in science and for applying their expertise in more applied fields such as medical technology, health and wellbeing, and game industry.

Content and structure

Students are expected to have a Bachelor's degree in science, medicine or engineering and have sufficient background in physics and mathematics. Teachers are recognized scientists in their research fields studying sensory systems and cognitive functions and developing brain research technologies. Curriculum reflects the research interests of the teaching faculty.

This major provides the students with up-to-date information on brain structure and function at different levels of analysis. In modern neuroscience, command of advanced statistical and signal-analysis methods is mandatory; therefore, specific courses are included to cover this supporting field. The imaging courses of this major provide the students with an overview and hands-on practice of modern brain research methods.

Besides the regular lecture and course work, part of the studies will take place in small groups under the guidance of a senior scientist. In the same vein, there is a compulsory special assignment, which exposes the student to a real research question and integrates him/her to a research team to learn the practices of the field and to develop his/her skills in reporting research.

Code	Course	Credits	Period/Year
Compulsory common courses of the programme (15 credits):			
MS-E2115	Experimental and Statistical Methods in Biological Sciences	5	I-II/1
JOIN-E3000	Life Science Technologies Project Course	10	III-V/1
Compulsory courses of the major (50 credits). **The courses can be replaced by courses with similar content when agreed with the responsible professor.**			
1 Neuroscience and imaging (35 credits)			
NBE-E4210	Structure and Operation of the Human Brain	5	I-II/1
NBE-E4000	Principles of Biomedical Imaging	5	I-II/1
NBE-E4225	Cognitive Neuroscience	5	III/1
NBE-E4240	Advanced Course on Human Neuroscience	5	IV-V/1
NBE-E4045	Functional Brain Imaging	5	I-II/2
NBE-E4500	Special Assignment in Human Neuroscience	10	I-V, Summer/1 or 2
2 Analysis and modelling (5 - 10 credits) Select from the courses below.			
NBE-E4050	Signal Processing in Biomedical Engineering	5	I-II/1
CS-E5710	Bayesian Data Analysis	5	I-II/2
CS-E3210	Machine Learning: Basic Principles	5	I/1 or 2
CS-E5740	Complex Networks	5	I-II/1 or 2
3 Supporting courses (5 - 10 credits). Select primarily from the ones below. Other relevant courses from other Life Science Technologies majors possible with an agreement of the responsible professor of the major.			
UH NEU-104	Interactive neurobiology (course at University of Helsinki)	5	I-II/1
NBE-E4120	Cellular Electrophysiology	5	I-II (even years)
NBE-E4130	Information Processing in Neural Circuits	5	III-V (odd years)
NBE-E4010	Medical Image Analysis	5	I-II (odd years)
NBE-E4020	Medical Imaging	5	III-IV (even years)

NBE-E4300	Medical Device Innovation	5	III-IV (even years)

Recommendations for elective studies

Students are encouraged to take courses from other Majors of the Life Sciences Technologies programme, depending on own interests. Those who are especially interested in neurotechnologies, can extend their knowledge profile by taking courses from Biomedical Engineering major and Biosensing and Bioelectronics major. Also internship is recommended in elective studies.

Elective studies 2017-2018

Students choose 25–30 credits of elective studies depending on the extent of the major. A minor and/or individual courses can be taken as elective studies. Individual courses can also be taken from other programmes at Aalto University or from other Finnish universities through Flexible Study Right (JOO). Students can also participate in an international student exchange programme or do an internship (1–10 ECTS) in Finland or abroad. Further information on Flexible Study Right and internship is available in Into:

Studies at other Aalto Schools or in Finnish Universities

Practical training

Further information on minors at Aalto is available on the pages Minors 2017-2018.

Master's thesis 2017-2018

Students are required to complete a master's thesis, which is a research assignment with a workload corresponding to 30 credits. The thesis is written on a topic usually related to the student's major and agreed between the student and a professor of the major. The supervisor of the thesis must be a professor in Aalto university and have a relevant expertise in the topic, whereas the thesis advisor(s) can be from the Aalto university, company or another university. Thesis advisor(s) must have at least a master's degree.

Master's thesis work includes a seminar or equivalent presentation. The student is also required to write a maturity essay related to the master's thesis.

The master's thesis is a public document and cannot be concealed in any part.

Topics of master's theses as well as final theses are approved in the Programme committee of Life Science Technologies. Approval of topic as well as approval and grading of thesis have to be applied for.

For further information and instructions, see

CHEM students Completing your master's thesis (old)

ELEC students Completing your master's thesis

SCI students https://mycourses.aalto.fi/course/view.php?id=19277

Language studies 2017-2018

Mandatory language studies are included as part of the Finnish bachelor's degree for students who have studied in Finland and whose language of education is Finnish or Swedish. If the mandatory language studies have not been completed in the Finnish bachelor's degree, the student must take 2 credits in the second national language and 3 credits in one foreign language, including both oral (o) and written (w) proficiency, as part of their master's degree.

Students who have received their education in a language other than Finnish or Swedish, or received their education abroad, are required to complete only 3 credits in one foreign language.

In the Master's Programme in Life Science Technologies, English is recommended as the mandatory foreign language.

Students who have received their education abroad and who already have excellent command of English (e.g. English as their first language) may choose 3 credits of Finnish courses instead, hence not covering the requirement of oral/written proficiency but meeting the language requirement of the degree. If this applies to you, please contact your school's Learning Services for further advice, as different schools have different procedures for validating this exemption.

Language studies are incorporated into students' elective studies.

Further information on relevant courses is available from the Language Centre: Language and communication studies