The Faculty of Engineering and Science

Board of Studies for Chemistry, Environmental Engineering and Biotechnology

AALBORG UNIVERSITY
DENMARK

Curriculum for Bachelor (BSc) in Sustainable Biotechnology

Aalborg University

September 2016

Version 2 - September 2018

Campus Copenhagen

Preface

Pursuant to Act no. 261 of March 18 2015 on Universities (The University Act) the following study regulations are stipulated.

The Study Regulations are approved by the Study Board of Biotechnology, Chemical and Environmental Engineering at Aalborg University. The study regulations cover the Bachelor Programme in Sustainable Biotechnology in Copenhagen.

Aalborg University, 2015

Niels T. Eriksen

Chairman of Study Board

Contents

Chapter 1: Legal basis of the study regulation

1.1 The Ministerial Order basis

The Bachelor program in Sustainable Biotechnology is organized in accordance with the Ministry of Science Order no. 1520 of December 16, 2013 on Bachelor's and Master's Programs at Universities (the Ministerial Order of the Study Programs) and order no. 670 of June 19. 2014 on exams at university educations (the ministerial order of exams). We also refer to order no. 257 of March 18, 2015 (the ministerial order of admittance) and order no. 114 of February 3, 2015 (the ministerial order of grades).

1.2 The Faculties of Engineering and Science affiliation

The Bachelor program falls under the Faculties of Engineering and Science, Aalborg University.

1.3 The Study Board affiliation

The programme fall under the Study Board for Biotechnology, Chemical and Environmental Engineering.

1.4 Board of External Examiners

The programme falls falls under the external evaluator corps: ingeniøruddannelernes censorkorps – Kemi retning

Chapter 2: Admission, degree/title, program duration and competence profile

2.1 Admission

Admission to the Bachelor programme in Sustainable Biotechnology requires an upper secondary school exam, mathematics on A-level, English B-level (or an acceptable IELTS score) and one of the following combinations:

Physics B and Chemistry B

Physics B and Biotechnology A

Geoscience A and Chemistry B

2.2 Degree/title in Danish and English

Successful completion of the Bachelor programme entitles the student to use the title Bachelor (BSc) i bæredygtig bioteknologi. The corresponding English title is: Bachelor (BSc) in Engineering (Sustainable Biotechnology).

2.3 The program's specification in ECTS

The Bachelor program is a 3-year, research based, full-time study program. The program is set to180 ECTS.

2.4 The program's competence profile

The competence profile below will appear on the diploma:

A graduate of the Bachelor programme has competences acquired through a course of study that has taken place in a research environment.

A graduate of the Bachelor programme has a basic knowledge and insight into the methods and scientific basis of sustainable biotechnology. These competences qualify the bachelor to subsequent education on a relevant master study and to employment based upon the education.

2.5 Description of qualifications:

Individuals who attain degrees at this level

Knowledge	• Have a research-based knowledge about theory, methods and practise within the biotechnological and sustainable biotechnological area. • Can understand and reflect on theories, scientific and technical methods, and practise. • Can understand the significance of sustainability to biotechnological energy, chemical, and material production
Skills	• Can use scientific methods and tools of the above-mentioned areas and use the general skills that are tied to work within sustainable biotechnology. • Are able to evaluate theories, methods, tools and general skills of sustainable biotechnology, and utilize these in a sustainable context. • Are able to communicate biotechnological problems and sustainable solutions based upon biotechnology to peers, non-specialists, collaborative partners and users.
Competences	• Are able to handle complex situations and tasks within sustainable and process-oriented problems in connection with study or work situations. • Are able to independently initiate and carry out discipline specific and cross-disciplinary cooperation and to assume professional responsibility within the area of sustainable biotechnology.

Chapter 3. The content and structure of the study program

The program is structured in modules and organized as a problem-based study. A module is a program element or a group of program elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within specific exam periods. The examinations are defined in the curriculum.

The program is based on a combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following work and evaluation methods that combine skills and reflection:

- ***lectures***
- ***classroom instruction***
- ***project work***
- ***workshops exercises (individually and in groups)***
- ***project work and exercises in labs***
- ***teacher feedback***

The BSc education in Sustainable Biotechnology is taught in English.

3.1 Overview of the program

All modules are assessed through individual grading according to the 7-point scale or Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or assessment by the supervisor only).

Semester	Module	ECTS	Bedømmelse	Prøve
1.	Linear Algebra	5	7-point scale	Intern
	Problem-based Learning in Science, Technology and Society	5	Pass/failed	Intern
	General and Organic Chemistry	5	7-point scale	Intern
	Biological Production - a Case Study	5	Pass/failed	Intern
	Biological Production	10	7-point scale	Intern
2.	Calculus	5	7-point scale	Intern
	Biomolecules and Biochemistry I	5	7-point scale	Intern
	Sustainability	5	7-point scale	Intern
	Biomass Conversion	15	7-point scale	Extern
3.	Energy and Resources	5	7-point scale	Intern
	Applied Biodiversity	5	7-point scale	Intern
	Kinetics and Process Modelling	5	7-point scale	Intern
	Electives a. Sustainable Production of Bioenergy b. Sustainable Production of Biochemicals	15	7-point scale	Intern
4.	Microbiological Processes	5	7-point scale	Intern
	Biochemistry II	5	7-point scale	Intern
	Process Technology	5	7-point scale	Intern
	The Cell as a Factory	15	7-point scale	Extern
5.	Applied Statistics	5	7-point scale	Intern
	Molecular Biology	5	7-point scale	Intern
	Cell Biology and Genetics	5	7-point scale	Intern
	Development of Recombinant Biocatalysts	15	7-point scale	Extern
6.	Biotechnology, Ethics and Society	5	7-point scale	Intern
	BSc Project	20	7-point scale	Extern
	Cases in Bioprocess Technology	5	7-point scale	Intern
SUM		180		

3.2 Theory of Science and Ethics

Theory of science, scientific methods and ethics are taught in the courses biological productionl project work (1. Semester) and Biotechnology, ethics and society (6. Semester).

1. Semester

3.4.1 Linear Algebra

Dansk titel *English title*	*Lineær algebra* *Linear Algebra*
Placement	***Autumn 1. semester***
Learning outcome	***After the course the student should be able to*** ***Knowledge*** ***understand differentiation and integration of simple mathematical functions.*** ***understand and interpret simple mathematical problems including solutions to differential equations.*** ***understand simple problems in linear algebra.*** ***Skills*** ***calculate differentials and integrals of simple functions*** ***solve ordinary 1st and 2nd order differential equations.*** ***solve systems of algebraic equations.***
Teaching form	***Lectures and exercises***
Content	***Use of derived functions. Integrals and integration techniques. Indefinite, definite and improper integrals. Use of definite integrals. Polar coordinates and parametric equations. Function series. Ordinary 1st and 2nd order differential equations. Partial differential equations. Linear algebra and analytical geometry. Vectors and Vector spaces. Determinant and linear systems. Matrices, determinants and linear equation systems.***
Duration ECTS	***5 ECTS***
Language	***English***
Assessment	***Internal 4 hours written exam. All aids allowed***
Marking	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.4.2 Problem Based Learning in Science, Technology and Society

Dansk titel	*Problembaseret læring i videnskab, teknologi og samfund*
English title	*Problem Based Learning in Science, Technology and Society*
Placement	***Autumn 1. semester***
Learning outcome	***After the course the student should have*** ***Knowledge*** ***knowledge of basic learning theories*** ***knowledge of project planning and management techniques*** ***different approaches to problem-based learning (PBL) including the Aalborg Model approach.*** ***An understanding of different ressources for analysis and assessment of biotechnology problems and solutions from scientific, thechnological, ethical and social perspectives.*** ***Skills*** ***The ability to apply basic principles related to planning and management of a problem-based project; basic study techniques, and phases in a problem-oriented project.*** ***Has the ability to analyse and evaluate the organization of the project group work and collaboration, especially regarding identification of strong and weak factors, and based on this, suggest how group organization and collaboration can be improved in future situations; team roles; group dynamics; communication within the group and externally; creativity; methods for analysis and documentation of learning processes.*** ***The ability to analyze group conflicts; causes and possible solutions.*** ***The ability to analyze own contribution to study and learning, especially regarding identification of strong and weak factors and based upon this, consider continuous courses of events and their contributions to the learning process.*** ***The ability to analyze methods used in the project from a scientific point of view; science theory, and qualitative and quantitative approaches.*** ***Competences*** ***The ability to understand and communicate project work*** ***The ability to analyze own learning processes***

	The ability to analyze and document learning processes within the group. ***The ability to create optimal collaborative learning processes*** ***The ability to evaluate professional situations in relation to the surrounding society.***
Teaching form	***Lectures, exercises and group work***
Content	
Duration ECTS	***5 ECTS***
Language	***English***
Assessment	***Internal 4 hours written exam. All aids allowed***
Marking	***Pass/fail***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.4.3 Biological Production – a Case Study

Dansk Titel *English Title*	*Biologisk produktion – et case studie* *Biological Production – a Case Study*
Placement	***Autumn 1. semester***
Learning outcome	***After the course the student should be able to*** ***Knowledge*** • • ***account for the working processes in project work*** • ***describe basic principles in a selected biological production method*** • ***describe basic principles of different biological production methods.*** ***Skills*** • ***plan a project work*** • ***use biological and chemical concepts and scientific presentation*** • ***Competences*** • ***be part of team-based project work.*** • ***communicate project work*** • ***reflect upon and develop own learning consciously*** • ***participate in and optimize collaborative learning processes***

Teaching form	***Lectures and project work.***
Content	***The project is a case study where the students should prepare a report and a process analysis, and participate in a seminar where the project team documents are discussed. A biological production technology for the production of food, feed, energy, biochemicals and/or commodities should be selected and its basic elements described. Lectures describing different biological production methods for inspiration.***
Duration ECTS	***5 ECTS***
Language	***English***
Assessment	***Participation in a seminar with presentation of the report and analysis of project work***
Marking	***Pass/fail***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.4.4 Biological Production

Dansk Titel	*Biologisk produktion*
English Title	*Biological Production*
Placement	***Autumn 1. semester***
Prerequisites	***This module is based on knowledge gained in Biological production - a case study***
Learning outcome	***After the course the student should be able to*** ***Knowledge*** ***describe techniques for planning and control of project work*** ***account for different biological production methods*** ***Skills*** ***use biological and chemical concepts and scientific presentation.*** ***carry out analyses of the selected biological production method(s) with respect to principles, sustainability, environment and economy.*** ***Competences*** ***be part of team-based project work.*** ***communicate project work*** ***reflect upon and develop own learning consciously*** ***participate in and optimize collaborative learning processes***

Teaching form	***Project work that may include some laboratory work.***
Content	***In the project one or more different biological production technologies are selected and analysed for the production of food, feed, energy, biochemicals and commodities. The analyses are carried out from technological, societal, ethical, environmental and economic considerations. Competences are also given within project work, project reporting and project analysis.***
Duration ECTS	***10 ECTS***
Language	***English***
Assessment	***Internal evaluation based upon report and oral examination***
Marking	***7-point scale.***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.4.5 General and Organic Chemistry

Dansk titel	*Almen og organisk kemi*
English title	*General and Organic Chemistry*
Placement	***Autumn 1. semester***
Learning outcome	***Students who pass the module*** ***Knowledge*** ***should know and understand the periodic table*** ***should understand chemical equilibria, chemical reactions, and basic thermodynamical principles.*** ***can account for acid/base and redox properties for important chemical compounds and elements*** ***can understand and account for nomenclature in organic chemistry, the structure of organic compounds and reaction mechanisms for organic compounds.*** ***can understand and account for safe laboratory practice and behavior.*** ***can understand basic analytical chemistry techniques (i.e. titration, spectrophotometry, chromatography).*** ***Skills*** ***can address fundamental characters for elements based upon their placement in the periodic system.*** ***can calculate the relation between ionized and unionized amount of an ionizable compound in water*** ***can characterize chemical compounds with respect to acid/base and oxidative/reductive properties.*** ***can evaluate how a chemical reaction will proceed based upon thermodynamic considerations.*** ***can read and understand state chart diagrams and calculate the concentration of a compound in the liquid and gas phase based upon gas-liquid equilibrium constants.*** ***can name organic compounds and account for basic organic reactions, their products and reaction mechanisms.*** ***Competences*** ***can use basic chemical and physical principles on biological and process technological problems*** ***can move and work safely in a chemical laboratory***
Teaching form	***Lectures, calculation exercises, laboratory exercises.***
Content	***The periodic system: atom structure, properties of the elements, the size of atoms and the significance of the***

	size. Covalent and non-covalent bindings; ionization and ionization energy, electron affinity and electronegativity; charge and mass balances; basic electrochemistry, potentiometry and electrodes. Separation techniques and chromatography; empirical properties and kinetic theories for gases. Aliphatic and aromatic carbon compounds; functional groups; stereochemistry and nomenclature. Acids, bases, buffers, solubility products, equilibria, reaction mechanisms, thermochemistry. Laboratory safety. Basic chemical laboratory exercises.
Duration ECTS	***5 ECTS***
Language	***English***
Assessment	***Oral or written exam. Approved active participation in the teaching is a prerequisite for participation in the regular exam.***
Marking	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.5 2. semester

3.5.1 Calculus

Dansk titel *English title*	*Calculus* *Calculus*
Placement	***Spring 2. semester***
Prerequisites	***The module builds om knowledge gained in Linear algebra or similar***
Teaching form	Lectures and calculation exercises
Learning outcome	***Students who have passed the module*** ***Knowledge*** • ***should have knowledge about definitions, results and techniques within the theory of differentiation and integration of functions of two or more variables.*** • ***should know trigonometric functions and their inverse functions.*** • ***should have knowledge about simple surfaces in right-angled, polar and spherical coordinates.*** • ***should have knowledge about complex numbers their calculation rules and representations.*** • ***should have knowledge about factorization of polynomia of complex numbers*** • ***should have knowledge about the complex exponential function, its properties and its connection with trigonometric functions.*** • ***should have knowledge about the theory for second order linear differential equations with constant coefficients.*** ***Skills*** • ***can visualize functions of two and three variables by means of graphs, level curves, and level planes*** • ***can determine local and global extremes for functions of two and three variables.*** • ***can determine area, volume, inertia moment by use of integration theory.*** • ***can approximate functions of a variable by means of Taylor's equation and use linear approximation for functions with two or three variables.*** • ***is capable of calculations using complex numbers*** • ***can find the roots of the complex quadratic equation and perform factorization of polynomia in simple cases.*** • ***can solve linear second order differential equations with constant coefficients, generally and with starting conditions.*** • ***can reason with the concepts, results, and theories of the course in simple concrete and abstract problems.***

	Competences • ***can develop and strengthen the knowledge, understanding and application of mathematical theories and methods within other fields*** • ***can reason and argue using mathematical concepts from given prerequisites.***
Duration ECTS	***5 ECTS***
Language	***English***
Assessment	***Internal oral or written examination***
Marking	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.5.3 Biomolecules and Biochemistry I

Dansk titel *English title*	*Biomolekyler og Biokemi I* *Biomolecules and Biochemistry I*
Placement	***Spring 2. semester***
Learning outcome	***Students who have passed the module*** ***Knowledge*** • ***can explain the properties of a broad diversity of biological molecules*** • ***can account for the basic synthesis of biological macromolecules (DNA/RNA/ protein/sugars, polysaccharides and lignin)*** • ***can account for degradation of lignocellulosic material*** • ***can account for the structureof biomolecules*** • ***can account for the structure and reproduction of prokaryote and eukaryote cells.*** ***Skills*** • ***can distinguish between anaerobic and aerobic organisms and basic metabolism*** • ***can outline basic properties of enzymes.*** • ***has a basic understanding of DNA replication, RNA and protein synthesis.*** • ***knows about prokaryote and eukaryote cell components, functions and division.*** • ***can use the gained knowledge in the project "Biomass conversion"*** ***Competences***

	• ***can evaluate whether processes are aerobic or anaerobic.*** • ***can understand which biochemical processes that are important in connection with the complex biotechnological processes in connection with biomass conversion e.g. in a biorefinery.***
Teaching form	***Lectures, group work, seminar calculation exercises.***
Duration ECTS	***5 ECTS***
Assessment	***Oral or written exam. Approved active participation in the teaching is a prerequisite for participation in the regular exam.***
Marks	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.5.4 Sustainability

Dansk titel *English title*	*Bæredygtighed* *Sustainability*
Placement	***Spring 2. semester***
Purpose	The purpose of the course is to give an overview of sustainability principles and a number of principles and methods that are parts of sustainability considerations.
Learning outcomes	After the course the student should be able to: Knowledge • Outline sustainability concepts related to energy, thermodynamics, nutrients, water, and greenhouse gases. Skills • Perform sustainability estimations and simple life cycle analyses. • Relate sustainability to societal perspectives. • Analyze biotechnological processes with respect to sustainability. Competences • Include ethical considerations in sustainability analyses. • Outline the relationships between sustainability and development and understand projections of resource and environmental issues including global and local models. • Include economic considerations in sustainability analyses.

Content	The course is arranged as 2 weekly theoretical exercises where each theme is initiated by a lecture given by staff members or by invited lecturers. The different themes (sustainability concepts; thermodynamics and sustainability; sustainability and life cycle analyses; sustainability and energy, nutrients, water, and greenhouse gases; bioethics and sustainability; economics, development, and sustainability) are treated in case studies as a basis for discussions in groups.
Duration in ECTS	***5 ECTS***
Language	***English***
Exam form	***Internal***
Assessment	Internal 4 hours written examination
Marking	***7-point scale***
Assessment criteria	***As stated in the Joint programme regulations***

3.5.4 Biomass Conversion

Dansk Titel	*Biomasse omdannelse*
English Title	*Biomass Conversion*
Placement	***Spring 2. semester***
Prerequisites	***The module builds on knowledge gained in Biological production, Biomolecules and BiochemistryI or similar***
Learning outcome	***After the course the student should be able to*** ***Knowledge*** • ***present an overview of plant or algae biomass as a resource*** • ***understand the basic structure of plants or algae and their cell walls*** • ***give an overview of plant or algae biomass conversion, including the need for pretreatment*** ***Skills*** • ***carry out simple analyses of plant or algae biomass with respect to its composition of main components (e.g. cellulose, hemi-cellulose, lignin etc.)*** • ***apply enzymes to degrade plant or algae biomass*** • ***be able to calculate the hydrolysis efficiency*** • ***be able to calculate theoretical yield of a biological production (e.g. conversion of the biomass into bioethanol)*** ***Competences***

	• ***define a biorefinery concept*** • ***apply sustainability criteria in the development of biorefinery concepts*** • ***estimate the environmental impact*** • ***understand the basis of carrying out experimental work***
Teaching form	***Lectures and project work including laboratory work.***
Content	***In the project, the students work with individual chosen biomasses which should be analyzed with respect to main composition. The biomass can be pretreated or, if possible, already pretreated by others and enzymes should be applied for conversion of the biomass into a sugar stream. This can be used for production of food, feed, energy, biochemicals and commodities. The analyses are carried out both from technological and sustainable considerations. Since plant biomass constitute the major resource for biological production, an introduction to algal, plant cells and plant cell walls will also be given. Competences are given within laboratory based work and writing of a report based on experimental data.***
Duration ECTS	***15 ECTS***
Language	***English***
Assessment	***Internal evaluation based upon report and individual oral examination***
Marking	***7-point scale.***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.6 3. semester

3.6.1 Energy and Resources

Dansk titel *English title*	*Energi og resourcer* *Energy and Resources*
Placement	***Autumn 3. semester***
Prerequisites	***The module builds on knowledge gained in General and organic chemistry or similar***
Learning outcome	Students who have passed the module Knowledge • can distinguish between fossil and renewable energy resources • have an overview of accessibility and sustainability related to different energy sources and their conversion processes. • have fundamental knowledge about the different energy forms (fuels, electricity, heat) and their energy quality. • can understand advantages and disadvantages of the different energy forms with respect to storage and transport. Skills • can calculate the energy content of a specific resource. • can use thermodynamics in chemical and biological reactions for the calculation of energy loss by transformation to a specific energy form and the final energy content by conversion to mechanical energy, electricity and heat. Competences • can evaluate the sustainability and efficiency of the production of a specific raw material and its conversion into energy.
Teaching form	***Lectures and calculation exercises***
Duration ECTS	5 ECTS
Content	Sustainable and non-sustainable raw material and energy ressources; thermodynamics of chemical and biological reactions and systems; quality of different energy forms; storage and transport of energy.
Assessment	***Internal 4 hours written exam***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.6.2 Applied Biodiversity

Dansk titel *English title*	*Anvendt biodiversitet* *Applied Biodiversity*
Placement	***Autumn 3. semester***
Prerequisites	***The module builds on knowledge gained in Biomolecules and Biochemistry I or similar***
Learning outcome	Students who have passed the module Knowledge • can account for microbial diversity • can account for the problems associated to classification and species concepts of microorganisms • can describe commercially important microorganisms • can evaluate conventions regulating commercial exploitation of microorganisms. • can describe different screening methods for new microorganisms. • can describe how genes with interesting properties can be isolated from natural environmental samples. • can account for basic bioinformatics needed to handle microbial diversity. Skills • can give an overview of bioinformatic tools associated to the handling of microbial biodiversity. • have an overview of the different laboratory techniques used for isolation and handling of different types of microorganisms.
Teaching form	***Lectures and classroom exercises***
Duration ECTS	***5 ECTS***
Content	***The general microbial diversity of fungi, bacteria and archaea is presented in this course. The actual and potential organisms that are used in biotechnology are discussed in detail and their ecology and growth characteristics are worked through together with the different laboratory techniques that are used for isolation and handling of the organisms.***
Assessment	***Internal 4-hours written examination***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.6.3 Kinetics and Process Modelling

Dansk titel *English titel*	*Kinetik og modellering af bioprocesser* *Kinetics and Modelling of Bioprocesses*
Placement	***Autumn 3. semester***
Prerequisites	The module builds on knowledge gained in Linear algebra, Calculus, Biomolecules and Biochemistry or similar
Learning outcome	***Students who have passed the module*** • Knowledge • can account for the kinetics of biochemical reactions. • understand how mathematic models are constructed for different processes and bioreactors. Skills • can determine the kinetics and calculate the relevant kinetic parameters for the processes in a bioreactor • can define the most important variables and make sufficient assumptions to be able to derive the mathematic model of a bioprocess. • can apply a mathematical model on a bioreactor. Competences • can use mathematical modeling for the design of biotechnological processes.
Teaching form	***Lectures and calculation exercises***
Duration ECTS	***5 ECTS***
Content	• Introduction to mathematical modeling and bioprocesses, applications and approach • The kinetics of enzymatic reactions, kinetics of cell growth, metabolism and inhibition, the effect of temperature and pH. • Mass balances and modeling of ideal bioreactors at steady-state and non-steady-state. • Examples of model development; manual estimation of process parameters based upon experimental data.
Assessment	***Internal 4-hours written exam***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.6.4 Sustainable Production of Bioenergy

Danish titel	*Bæredygtig produktion af bioenergi*
English titel	*Sustainable Production of Bioenergy*
Placement	***Autumn 3. semester***
Prerequisites	The module builds on knowledge gained in Biomass conversion, Biomolecules and Biochemistry I or similar.
Learning outcome	***Students who have passed the module*** Knowledge • have knowledge about current and potential possibilities to replace fossil-based energy by bioenergy through sustainable biotechnological processes. • can account for the potential of biomass as a renewable resource for energy production. • can explain how different biofuels can be produced by microorganisms • can account for different pretreatment methods in relation to different types of biomass and biofuels. Skills • can suggest a suitable pretreatment and microbial process for the production of biofuels from a specific biomass. • can design and perform simple laboratory-scale fermentations with pure or mixed microbial cultures. • can analyze substrates, intermediates and end products, derive significant information from experimental data and calculate yields and production rates for the production of biofuels. Competences • can evaluate the efficiency of the production of a specific biofuel based upon experimental data.
Teaching form	***Project work***
Duration ECTS	15 ECTS
Content	• Introduction to energy and material use and resources, environmental aspects and biomass as energy. • Definition, types, accessibility and characteristics of raw materials for biofuels production. • Microbial conversion of biomass and microbial metabolism related to specific biofuels production. • Different pretreatment methods in relation to biomass and biofuels production. • Laboratory scale experiments on microbial production of biofuels. • Analyses of substrates, intermediate and end products and calculation of yields and productivity of biofuels production.

Assessment	***Internal oral examination based upon the written project report and project presentation.***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.6.5 Sustainable Production of Biochemicals

Danish titel *English titel*	*Bæredygtig produktion af biokemikalier* *Sustainable Production of Biochemicals*
Placement	***Autumn 3. semester***
Prerequisites	The module builds on knowledge gained in Biomass conversion, Biomolecules and Biochemistry I or similar.
Learning outcome	***Students who have passed the module*** Knowledge • have knowledge about current and potential possibilities to replace fossil-based chemicals by biochemicals through sustainable biotechnological processes. • can account for the potential of biomass as a renewable resource for chemical production. • can explain how different biochemicals can be produced by microorganisms • can account for different pretreatment methods in relation to different types of biomass and bioproducts. Skills • can suggest a suitable pretreatment and microbial process for the production of biochemicals from a specific biomass. • can design and perform simple laboratory-scale fermentations with a pure microbial culture. • can analyze substrates, intermediates and end products, derive significant information from experimental data and calculate yields and production rates for the production of biochemicals. Competences • can evaluate the efficiency of the production of a specific biochemical based upon experimental data.
Teaching form	***Project work***
Duration ECTS	15 ECTS
Content	• Introduction to material use and resources, environmental aspects and biomass as material resources.

	• Definition, types, accessibility and characteristics of raw materials for biochemicals production. • Microbial conversion of biomass and microbial metabolism related to specific biochmicals production. • Different pretreatment methods in relation to biomass and biochemicals production. • Laboratory scale experiments on microbial production of biochemicals. • Analyses of substrates, intermediate and end products and calculation of yields and productivity of biochemicals production.
Assessment	***Internal oral examination based upon the written project report and project presentation.***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.7 4. semester

3.7.1 Process Technology

Dansk titel *English titel*	*Procesteknologi* *Process Technology*
Placement	***Spring 4. semester***
Prerequisites	***The module builds on knowledge gained in Linear algebra, Calculus, General and organic chemistry or similar***
Learning outcome	***Students who have passed the module*** Knowledge • know the most common physical variables and their dimensions and units. • can understand unit conversion between physical variables. • can interpret process diagrams and flow sheets. • knows the principles of the most common unit operations • can understand the stoichiometry in chemical processes. Skills • can construct diagrams and flow sheets or simple processes. • can define system boundaries • can set up mass and/or energy balances for single step or multistep processes in which chemical reactions are a part. • can solve algebraic or differential equations from a mass or energy balance and define the operative conditions of the system. • can use thermodynamic functions to calculate enthalpy changes and equilibria in chemical processes. Competences • can analyze and design simple chemical processes
Teaching form	Lectures and calculation exercises
Duration ECTS	5 ECTS
Content	• Introduction to chemical and biochemical processes. • Basic engineer calculations • Set up of process diagrams • Matter and energy balances at steady and non-steady state. • Liquid flow and mixing • Heat and mass transfer • Unit operations • Homogeneous and heterogeneous reactions

	• Thermodynamic analyses of chemical reactions and equilibria.
Assessment	***Internal 4-hours written exam***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.7.2 Microbiological Processes

Dansk titel *English title*	*Mikrobiologiske processer* *Microbiological Processes*
Placement	***Spring 4. semester***
Prerequisites	***The module builds on knowledge gained in Biomolecules and Biochemistry I, and Applied Biodiversity or similar***
Learning outcome	***Students who have passed the module*** Knowledge • can present an overview over microbial physiological diversity. • can describe the differences between prokaryotes and eukaryotes, archaea, fungi and algae. • can account for microbial interactions • can explain how different types of fermentative, respiring and photosynthetic microorganisms produce energy. • can describe microbial turnover of different compounds including nutrient and carbon cycles. • can account for industrial use of microorganisms. Skills • can establish mass and energy balances for microbial conversion. • has an overview of important microbial interactions. • can evaluate potential risks and safety measures when handling microorganisms.
Teaching form	***Lectures and calculation exercises***
Duration ECTS	5 ECTS
Content	Modern biotechnology is to a large degree based upon the huge metabolic diversity of the microbial world. The most important of the microbial pathway types are presented and compared across the organismal groups. Also interesting pathways that so far are not exploited will be presented. Special metabolic pathways, energy metabolism and production of secondary metabolites will be discussed.
Assessment	***Internal 4 hours written examination.***

Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.7.3 Biochemistry II

Dansk titel *English title*	*Biokemi II* *Biochemistry II*
Placement	***Spring 4. semester***
Prerequisites	***The module builds on knowledge gained in General and organic chemistry, Biomolecules and Biochemistry I or similar***
Learning outcome	***Students who have passed the module*** Knowledge • ***can account for the synthesis of biological macromolecules (DNA/RNA and protein)*** • ***can account for the structure, function and regulation of biomolecules*** • ***can account for Michaelis-Menten enzyme kinetics.*** • ***can account for the energy metabolism of cellular systems.*** • ***can account for basic metabolic pathways*** ***Skills*** • ***can describe the structure and function of lipids, cell membranes and membrane proteins.*** • ***can give an overview of important metabolic pathways (glycolysis, citric acid cyclus, oxidative phosphorylation, glyconeogenesis, photosynthesis, Calvin cyclus, pentose phosphate synthesis, protein metabolism and amino acid catabolism and fatty acid metabolism.*** • ***has an understanding of DNA replication, RNA and protein synthesis.*** • ***can use the gained knowledge in the project "The cell as a factory"*** ***Competences*** • ***can evaluate whether processes are anabolic or catabolic and whether processes are primary metabolic or secondary metabolic.*** • ***can understand which biochemical processes that are important in connection with the complex biotechnological processes in e.g. a biorefinery.***
Teaching form	***Lectures, group work, seminar calculation exercises.***
Duration ECTS	***5 ECTS***

Assessment	***Internal 4 hours written examination.***
Marks	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.7.4 The cell as a Factory

Danish titel *English title*	*Cellen som fabrik* *The Cell as a Factory*
Placement	***Spring 2. semester***
Prerequisites	***The module builds on knowledge gained in Biological production, Biomass conversion, Biomolecules and Biochemistry I or similar***
Purpose	***To give a fundamental insight into the organization of the biochemistry on the cellular level and how and when this can be exploited in microbial fermentations.***
Leaning outcome	***Students who pass the module*** ***Knowledge*** • ***can account for biochemical synthesis pathways that can lead to the production of defined products in the project.*** • ***can account for how biochemical synthesis pathways can be up-regulated for an efficient production of selected products.*** • ***have an overview of the significance of pathway engineering on energy balances in cells designed to produce selected products.*** • ***understand bioinformatic and modeling tools for the development of cell factories.*** • ***can account for microbial growth conditions, microbial growth and how this is affected by temperature and pH and how this can be exploited for microbial production.*** • ***can account for the structure, biological function and use of enzymes and enzyme-catalyzed processes.*** ***Skills*** • ***can plan and perform experiments relevant to the project of the course.*** • ***can account for production, development and harvest of microbial metabolites and industrial enzymes in bacteria, yeast, and filamentous fungi, and the development of recombinant production strains.*** ***Competences***

	• ***can use the project work as a study form including the presented methods for organization of the group collaboration and solving of group conflicts.*** • ***can analyze own learning process.*** • ***can organize group work and collaborate with supervisors.*** • ***can communicate the results and processes of the project in a structured and understandable way, in writing, graphically and orally.***
Teaching form	***Case-study, project work, laboratory experiments***
Duration ECTS	15 ECTS
Content	The project is partially practical including work with one or more cell types (prokaryotic or eukaryotic) in fermentation experiments, where the dynamics and regulation of the cells are investigated. The project is closely associated to the parallel course in biochemistry, and the fermentation experiments are analyzed based upon the metabolism and known pathways of the cells. An introduction to analytical chemistry relevant to the project (HPLC, GC, etc.) is given.
Assessment	***External evaluation based upon report and oral examination***
Marks	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.8 5. semester

3.8.1 Applied Statistics

Dansk titel *English titel*	*Anvendt statistik* *Applied Statistics*
Placement	***Autumn 5. semester***
Prerequisites	***The module builds on knowledge gained in Linear algebra and Calculus***
Learning outcome	***Students who have passed the module*** ***Knowledge*** • ***Must have knowledge about basic concepts of probability theory, statistics and quality control*** • ***Must have knowledge about using MATLAB, including the Statistic TOOLBOX for solving problems in statistics and quality control*** ***Skills*** • ***Must be able to choose the right probability model and perform calculations according to the model. This applies to both discrete and continuous distributions.*** • ***Must be able to handle both one-dimensional as well as multi-dimensional random variables and the related distributions, discrete and continuous.*** • ***Must be able to calculate the mean, standard deviation for one-dimensional random variables and also be introduced into the calculation and understanding of covariance for multi-dimensional random variables.*** • ***Must be able to select the right statistical method and make calculations of confidence intervals and do hypothesis testing for one and two random samples, make analysis of variance and regression analysis in terms of continuous as well as discrete probability distributions.*** • ***Must be able to establish and solve problems in process control and product control, this applies both within continuous as an alternative variation.*** • ***Must be able to handle both traditional solution techniques as well as MATLAB solutions.*** • ***Must be able to interpret the results obtained from the correct statistical method including their application*** • ***Must be able to set up and use non-parametric tests on qualitative data***

	Competences • ***Must be able to engage in a dialogue regarding the optimal choice of method within probability theory, statistics and quality control.*** • ***Must be able to disseminate the results of the calculations to others, including colleagues, public authorities, etc.***
Teaching form	***Lectures and exercises***
Duration ECTS	***5 ECTS***
Assessment	***Internal written or oral examination***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.8.2 Molecular Biology

Dansk titel	*Molekylærbiologi*
English titel	*Molecular Biology*
Placement	***Autum 5. semester***
Prerequisites	***The module builds on knowledge gained in Biomolecuels and Biochemistry I, Biochemistry II or similar***
Learning outcome	***Students who have passed the module*** Knowledge • can account for the central dogma and its implicationscan account for the nature, organization and replication of the genetic material in prokaryotes as well as in eukaryotes. • can account for the structure and regulation of genes including *cis*- and *trans*- regulatory elements. • can account for transcription and translation in prokaryotes as well as in eukaryotes including the operon model, protein synthesis, and the genetic code. • can account for the theory behind central molecular biological methods - especially methods that can be used for modification and monitoring of biotechnologically relevant organisms. • can understand the principles behind the so-called "omics" technologies. • Can understand the most simple bioinformatics tools. Skills • can use selected molecular biological methods

	• can plan a series of experiments to modify an organism from the methods learned during the course • can describe the applications of genetically engineered organisms in biotechnology including considerations related to ethics and safety. • can use blast and elementary algoritms for molecular biological phylogeny
Teaching form	Lectures, laboratory exercises
Duration ECTS	5 ECTS
Content	• The structure and organization of the genetic material including DNA, RNA, the bacterial genome, plasmids. • Replication of DNA including segregation and mitosis • Genetic variation, mutation, repair mechanisms, recombination,mobile genetic elements, transcription factors. • Transcription and translation, operons, RNA synthesis, mRNA splicing, protein synthesis, the genetic code. • Molecular biological methods in theory and practice focusing on methods for genetic modification of microorganisms for production and other biotechnological purposes. • Genomics, transcriptomics and proteomics. • Introduction to simple molecular biology phylogenetical tools.
Assessment	***Internal 4-hours written examination***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.8.3 Cell Biology and Genetics

Dansk titel *English titel*	*Cellebiologi og Genetik* *Cell Biology and Genetics*
Placement	***Autum 5. semester***
Prerequisites	***The module builds on knowledge gained in Biomolecuels and Biochemistry I, Biochemistry II or similar***
Learning outcome	***Students who have passed the module*** Knowledge • can understand the central principles within classical genetics • can describe how genetic variation can arise, including mutations, recombination of DNA and exchange of genetic material between individuals/species. • can account for the background of heredity

	• can describe the construction of prokaryotic cells • can describe the construction of eukaryotic cells and their organelles • can account for communication between cells Skills • can describe the classical and the modern genetics • can describe the differences between prokaryotic and eukaryotic cells
Teaching form	Lectures, calculation exercises
Duration ECTS	5 ECTS
Content	• Classical genetics • Chromosomes and heridity • The structure and organization of the genetic material • Genetic variation, mutations, conjugation, transfection, transformation, mitosis, meiosis, mobile genetic elements. • The prokaryotic and eukaryotic cells • The eukaryotic organelles and their function
Assessment	***Internal 4-hours written examination***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.8.5 Development of Recombinant Biocatalysts

Dansk titel	*Udvikling af rekombinante biokatalysatorer*
English titel	*Development of Recombinant Biocatalysts*
Placement	***Autumn 5. semester***
Prerequisites	***The module builds on knowledge gained in Biomolecules and Biochemistry I, Biochemistry II, Microbiological processes or similar***
Learning outcome	***Students who have passed the module*** Knowledge • can describe the different steps in development of a selected biocatalysist with respect to cloning and transformation technologies as well as specific assays for testing the recombinant biocatalysts. • has knowledge on molecular biological techniques and basic bioinformatic tools. Skills • hands on experience with common good laboratory practices (GLP) for working with recombinant microorganisms

	• hands on experience with sterile techniques • experience with basic microbial and molecular biological methods Competences • can design a molecular project. • Is able to work independently in a laboratory environment • can reflect upon and develop own learning processes.
Teaching form	***Project work***
Duration ECTS	***15***
Content	***In the project, a selected biocatalyst is designed and developed. The work includes design and construction of plasmids using different molecular techniques (e.g restriction enzyme based cloning and/or PCR based cloning), selection of relevant selection markers, transformation of E. coli, selection of correct E. coli clones, plasmid preparation and transformation of relevant host (if another host than E. coli is chosen) and selection and use of assays for testing and evaluation of the heterologous expressed gene(s). The project report should include a theoretical part and an experimental part with results and conclusion of the laboratory work.***
Assessment	***External oral exam based upon the project report and the presentation of the project.***
Marking	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.9 6. semester

3.9.1 3.9.3 Biotechnology, Ethics and Society

Dansk titel *English titel*	*Bioteknologi, etik og samfund* *Biotechnology, Ethics and Society*
Placement	***Spring 6. semester***
Prerequisites	
Learning outcome	***Students who have passed the module*** ***Knowledge*** • ***can understand basic theory of science concepts, theories and methods related to civil engineering emphasizing biotechnological issues.*** • ***can use theory of science and ethical considerations in a societal context.*** ***Skills*** • ***can account for ethical considerations in connection with biotechnological issues.***
Teaching form	***Lectures, discussions***
Content	***Ethical issues presented through cases and discussions of complex dilemmas; presentation of central concepts on scientific argumentation and method; the history of civil engineering and its placement in society and science***
Assessment	***Internal oral examination***
Evaluation criteria	***As stated in the Joint programme regulations.***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.9.2 Cases in Bioprocess Technology

Dansk titel *English titel*	*Cases i bioproces teknologi* *Cases in Bioprocess Technology*
Placement	***Spring 6. semester***
Prerequisites	**The module builds on knowledge gained in Linear algebra, General and Organic Chemistry, Process Technology or similar**
Learning outcome	***Students who have passed the module*** Knowledge

	• can account for how to transfer knowledge of microbial processes and their kinetics into large-scale production processes. • have knowledge about special fermentation processes and the use of gene modified organisms (GMO). • have knowledge about bioreactor types, their design and possibility for up scaling. • can account for substrate preparation and handling and operation of production facilities. • can account for different unit processes needed for the conversion of biomass into industrial products. Skills • can set up, design, and compose different unit processes for the conversion of biomass into specific products.
Teaching form	***Lectures, laboratory exercises, calculation exercises***
Duration ECTS	***5 ECTS***
Content	Unit processes needed for the conversion of biomass into biobased products; pretreatment of substrate and biomass; sterilization of substrates and installations; design of fermentation processes; transferring biochemical reactions, their stoichiometry, rates and yields into production processes; bioreactor types - design and function; up scaling of biotechnological production; bioprocesses using GMO´s; cases for different industrial process schemes including wastewater treatment, energy production and production of bio-based chemicals.
Assessment	***Written 4-hours exam***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

3.9.3 BSc project

Dansk titel *English titel*	*Bachelorprojekt* *BSc Project*
Placement	***Spring***
Prerequisites	
Learning outcome	***Students who have passed the module*** Skills

	• can carry out and report an independent experimental and/or theoretical project work within sustainable biotechnology. Competences • have gained the skill of critical independent reflection within a biotechnological topic related to existing knowledge. • can include sustainability and application considerations in the evaluation of a project. • can elaborate a precise well-balanced written and oral communication of the results and conclusions of a project.
Teaching form	***Project work***
Duration ECTS	***20 ECTS***
Content	***The final project can take a starting point in one of the projects produced at an earlier semester or can be a new project. The project can be carried out within or in collaboration with a company or as an independent project on the university. The project can be theoretical or experimental but has to include sustainability and application considerations.***
Assessment	***External oral examination based upon the project report and the presentation of the project.***
Grade	***7-point scale***
Evaluation criteria	***As stated in the Joint programme regulations.***

Chapter 4: Entry into force, interim provisions and revision

The study regulations are adopted by the Study Board of Biotechnology, Chemical and Environmental Engineering, approved by the Dean of the Faculty of Engineering and Science and take effect from 1st September, 2016.

Students who wish to complete their studies under the former study regulations from 2014 must conclude their education by the summer examination period 2018 at the latest, since examinations under the former study regulations are not offered after this time.

The current, valid version of the study regulations is published at http://www.ses.aau.dk

Chapter 5: Other Provisions

5.1 Rules concerning written work, including the Bachelor's project

Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as „Pass" on the basis of good language performance alone; similarly, an examination normally cannot be assessed as „Fail" on the basis of poor language performance alone.

The study board can grant exemption from this in special cases (e.g., dyslexia).

The Bachelor's project must include an English summary and a Danish summary if the report is written by Danish students. The summary must be at least 1 page and not more than 2 pages (this is not included in any fixed minimum and maximum number of pages per student). The summary is included in the evaluation of the project as a whole.

In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's spelling and writing ability, in addition to the academic content.

5.2 Rules concerning credit transfer (merit), including the possibility for choice of modules that are part of another program at a university in Denmark or abroad

In the individual case, the study board can approve successfully completed (passed) program elements from other Master's programs in lieu of program elements in this program (credit transfer). The study board can also approve successfully completed (passed) program elements from another Danish program or a program outside of Denmark at the same level in lieu of program elements within this curriculum. Decisions on credit transfer are made by the study board based on an academic assessment. See the Joint programme regulations for the rules on credit transfer.

5.3 Rules concerning the progress and completion of the Bachelor's program

The student must participate in all first year examinations by the end of the first year of study in the Bachelor's program, in order to be able to continue the program. The first year of study must be passed by the end of the second year of study, in order that the student can continue his/her Bachelor's program.

In special cases, however, there may be exemption from the above if the student has been on a leave of absence. Leave is granted during first year of study only in the event of maternity, adoption, military service, UN service or where there are exceptional circumstances.

5.4 Rules concerning the completion of the Bachelor's program

The Bachelor's program must be completed no later than six years after it was begun. 52

5.5 Special project process

In the 3rd, 4th and 5th semesters, the student can upon application, design an educational pro- gram where the project work is replaced by other study activities; cf. the Joint programme regulations section 9.3.1.

5.6 Rules for examinations

The rules for examinations are stated in the Examination Policies and Procedures published by the Faculty of Engineering and Science on their website.

5.7 Exemption

In exceptional circumstances, the study board can grant exemption from those parts of the curriculum that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

5.8 Rules and requirements for the reading of texts in foreign languages and a statement of the foreign language knowledge this assumes

5.9 Additional information

The current version of the curriculum is published on the School's website, including more detailed information about the program, including exams. It is assumed that the student can read academic texts and in modern English and use reference works and similar.

5.10 New version of the curriculum September 2018

From September 2018 active participation in the teaching has to be approved for participation in the ordinary exam for the modules; Genreal and Organic Chemistry and the module Biomolecules and Biocehemsitry I