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 2014

Campus Copenhagen

Preface

Pursuant to Act no. 367 of March 25 2013 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, 2014

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. 666 of June 24. 2012 on exams at university educations (the ministerial order of exams). We also refer to order no. 1487 of December 16, 2013 (the ministerial order of admittance) and order no. 250 of March 15, 2007 (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.

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, physics on B-level and chemistry on B-level/biotechnology on A-level, English B-level (or an acceptable IELTS score)

2.2 Degree/title in Danish, Latin 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
- reflection
- portfolio work

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
	Biochemistry		10	7-point scale	Intern
	The Cell as a Factory		15	7-point scale	Extern
3.	Energy and Resources		5	7-point scale	Intern
	Applied Microbiological Diversity		10	7-point scale	Intern
	Bioenergy		15	7-point scale	Intern
4.	Genetics and Molecular Biology		10	7-point scale	Intern
	Process Technology		5	7-point scale	Intern
	Sustainable Biotechnology		15	7-point scale	Extern
5.	Statistics and Experimental Design		5	Pass/failed	Intern
	Cases in Bioprocess Technology		5	7-point scale	Intern
	Kinetics and Modeling of Bioprocesses		5	7-point scale	Intern
	Elec-tives	Development of Recombinant Biocatalysts	15	7-point scale	Extern
		Sustainable Biotechnological Companies	15	7-point-scale	Extern
6.	Biotechnology, Ethics and Society		5	Pass/failed	Intern
	BSc Project		15	7-point scale	Extern
	Optional Courses *		10		
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).

3.3 Optional courses

The bachelor education leaves the opportunity for the student to establish an individual profile of his/her education. This freedom of choice is achieved by individual choice of projects in the project modules and by the possibility of

choosing 10 ECTS courses from other educations on the 6th semester. The list is published at www.ses.aau.dk

3.4 1. Semester

3.4.1 Linear Algebra

Dansk titel **English title**	**Lineær algebra** **Linear Algebra**
Placement	Autumn
Prerequisites	Mathematics on A-level
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 grade
Evaluation criteria	As stated in the framework provisions.

3.4.2 Problem Based Learning in Science, Technology and Society

Dansk titel English title	Problembaseret læring i videnskab, teknologi og samfund Problem Based Learning in Science, Technology and Society
Placement	Autumn
Prerequisites	No special requisites
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 framework provisions.

3.4.3 Biological Production Cases

Dansk Titel **English Title**	**Biologisk produktion – et case studie** **Biological Production – a Case Study**
Placement	Autumn
Prerequisites	
Learning outcome	After the course the student should be able to Knowledge • should know how to plan and control of project work • account for the working processes in project work • of basic principles in a selected biological production method Skills • use biological and chemical concepts and scientific presentation • should be able to describe basic principles of different biological production methods. 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 Since plant biomass constitutes the major resource for biological production, an introduction to algal, plant cells and plant cell walls will also be given.
Duration ECTS	5 ECTS
Language	English
Assessment	Participation in a seminar with presentation of the report and analysis of project work
Marking	Passed/non-passed.
Evaluation criteria	As stated in the framework provisions.

3.4.4 Biological Production

Dansk Titel **English Title**	**Biologisk produktion** **Biological Production**
Placement	Autumn
Prerequisites	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 • present an overview of plant and algal biomass as a resource including a comprehension of the basic structure of algae, plants and plant cell walls. 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	According to the 7-point scale.
Evaluation criteria	As stated in the framework provisions.

3.4.5 General and Organic Chemistry

Dansk titel **English title**	**Almen og organisk kemi** **General and Organic Chemistry**
Placement	Autumn
Prerequisites	
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	Internal 4-hours written exam
Marking	7-point grade
Evaluation criteria	As stated in the framework provisions.

3.5 2. semester

3.5.1 Calculus

Dansk titel	**Calculus**
English title	**Calculus**
Placement	Spring
Prerequisites	Linear algebra
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; 7-point scale.
Evaluation criteria	As stated in the framework provisions.

3.5.2 Biochemistry

Dansk titel **English title**	**Biokemi** **Biochemistry**
Placement	Spring
Prerequisites	General and organic chemistry
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 • can account for the structure and reproduction of prokaryote and eukaryote cells. • Skills • can distinguish between anaerobic and aerobic metabolism • can outline basic properties, kinetics and catalytic and regulatory mechanisms of enzymes. • 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. • knows about prokaryote and eukaryote cell components, functions and division. • can use the gained knowledge in the project "The cell as a factory" • Competences • can evaluate whether processes are aerobic or anaerobic. • 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	10 ECTS
Assessment	Internal 4 hours written examination.

Marks	7-point scale
Evaluation criteria	As stated in the framework provisions.

3.5.3 The cell as a factory

Danish titel **English title**	**Cellen som fabrik** **The Cell as a Factory**
Placement	Spring
Prerequisites	Biological production
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 framework provisions.

3.6 3. semester

3.6.1 Energy and Resources

Dansk titel **English title**	**Energi og resourcer** **Energy and Resources**
Placement	Autumn
Prerequisites	General and organic chemistry
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 framework provisions.

3.6.2 Applied microbiological biodiversity

Dansk titel **English title**	**Anvendt mikrobiel biodiversitet** **Applied Microbiological Biodiversity**
Placement	Autumn
Prerequisites	Biochemistry
Learning outcome	Students who have passed the module Knowledge • can present an overview over microbial organismal and physiological diversity. • can describe the differences between prokaryotes and eukaryotes, archaea, fungi and algae. • 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.

	• 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	10 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 and the responsible organisms are presented and compared across the organismal groups. 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. 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 framework provisions.

3.6.3 Bioenergy

Danish titel	**Bioenergi**
English titel	**Bioenergy**
Placement	Autumn
Prerequisites	Biological production, The cell as a factory, Biochemistry
Learning outcome	Students who have passed the module Knowledge • has knowledge about environmental considerations

	related to the use of fossil fuels. • can account for the potential of biomass as an energy resource. • can explain how different biofuels can be produced by microorganisms • can account for different pretreatment methods in relation to different biomass types and biofuels. • can work with biofuel production in laboratory scale. Skills • can suggest a suitable pretreatment and microbial process for biofuel production from a specific biomass. • can design and perform simple laboratory-scale fermentations with pure or mixed microbial cultures. • can analyze substrates, intermediate and end products, derive significant information from experimental data and calculate yields and production rates. Competences • can evaluate the efficiency of a specific biofuel production based upon experimental data.
Teaching form	Project work
Duration ECTS	15 ECTS
Content	• Introduction to energy use, energy resources, environmental questions and biomass as energy resource. • definition, types, accessibility and characteristics of raw materials for biofuel production. • microbial conversion of biomass and microbial metabolism related to specific biofuel production (methane, ethanol, butanol, hydrogen, and biodiesel). • different pretreatment methods in relation to biomass and biofuel production. • laboratory scale experiments on microbial production of biofuels. • analyses of substrates, intermediate and end products and calculation of yields and efficiency in relation to energy production and conservation.
Assessment	Internal oral examination based upon the written project report and the project presentation.
Grade	7-point scale
Evaluation criteria	As stated in the framework provisions.

3.7 4. semester

3.7.1 Genetics and Molecular Biology

Dansk titel **English titel**	**Genetik og molekylærbiologi** **Genetics and Molecular Biology**
Placement	Spring
Prerequisites	Biochemistry
Learning outcome	Students who have passed the module Knowledge • can understand the central principles within classical genetics • can account for the nature, organization and replication of the genetic material in prokaryotes as well as in eukaryotes. • knows how genetic variation can arise, including mutations, recombination of DNA and exchange of genetic material between individuals/species. • 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. 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.
Teaching form	Lectures, laboratory exercises
Duration ECTS	10 ECTS
Content	• Classical genetics • 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, meiosis, 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.
Assessment	Internal 4-hours written examination
Grade	7-point scale
Evaluation criteria	As stated in the framework provisions.

3.7.2 Process Technology

Dansk titel **English titel**	**Procesteknologi** **Process Technology**
Placement	Spring
Prerequisites	Linear algebra, Calculus, General and organic chemistry
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 framework provisions.

3.7.3 Sustainable Biotechnology

Dansk titel **English titel**	**Bæredygtig bioteknologi** **Sustainable Biotechnology**
Placement	Autumn
Prerequisites	Biological production, The cell as a factory, Bioenergy
Learning outcome	Students who have passed the module Knowledge • know current and potential possibilities to replace fossil-based technology for the production of materials and chemicals by sustainable biotechnological production processes. Skills • can select and combine alternative physical-chemical and biotechnological processes for sustainable production of specific products. • can evaluate the technical possibilities for the use of specific biotechnological processes. • can evaluate and estimate the economic costs of a biotechnological process. • can perform an environmental analysis of a biotechnological process. • can establish the necessary data to make a life-cycle analysis.

	Competences • posses a broad understanding for the use of fermentation and other biotechnological processes in combination with process technology and for the possibilities of replacing chemical and fossil resource-based technology with sustainable biotechnological solutions.
Teaching form	Project work
Duration ECTS	15 ECTS
Content	During the project one or more processes for sustainable biotechnological production or conversion for replacement of fossil resource based technologies are worked on. The project can involve chemical and/or environmental processes and consist of as well biological, chemical as process technological analyses and solution models. An introduction to lifecycle analyses and simple economic evaluations and analyses is given. Also case-based analyses of sustainable biotechnological production of e.g. commodity chemicals, biopolymers and plastic, medicine and food additives are given.
Assessment	Oral examination based upon the report and the project presentation.
Grade	7-point scale
Evaluation criteria	As stated in the framework provisions.

3.8 5. semester

3.8.1 Statistics and Experimental Design

Dansk titel **English titel**	**Statistik og forsøgsplanlægning** **Statistics and Experimental Design**
Placement	Autumn
Prerequisites	Linear algebra, general and organic chemistry
Learning outcome	Students who have passed the module Knowledge • can choose among and utilize a number of common statistical methods to obtain a practical and usable interpretation of gained results. • Skills • can use statistical research planning within quality and process optimization.
Teaching form	Lectures and calculation exercises

Duration ECTS	5 ECTS
Content	Basic statistic concepts; probability calculation including different distributions, statistical variables and practical calculations of probabilities; set up of research plans with qualitative and quantitative factors; analysis of production data, derived data; optimization experiments; control experiments.
Assessment	Internal written examination
Grade	Pass/fail
Evaluation criteria	As stated in the framework provisions.

3.8.2 Cases in Bioprocess technology

Dansk titel **English titel**	**Cases i bioproces teknologi** **Cases in Bioprocess Technology**
Placement	Autumn
Prerequisites	Linear algebra, general and organic chemistry, process technology
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 framework provisions.

3.8.3 Kinetics and modeling of bioprocesses

Dansk titel **English titel**	**Kinetik og modellering af bioprocesser** **Kinetics and Modelling of Bioprocesses**
Placement	Autumn
Prerequisites	Linear algebra, Calculus and Biochemistry
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 framework provisions.

3.8.4 Sustainable Biotechnological Companies

Dansk titel **English titel**	**Bæredygtige bioteknologiske virksomheder** **Sustainable Biotechnological Companies**
Placement	Autumn
Prerequisites	Sustainable Biotechnology
Learning outcome	Students who have passed the module Knowledge • can describe a biotechnological production company with respect to substrates, organisms and processes. • have knowledge on how to establish a business plan and a budget for expenditure and establishment. • can work out a life-cycle analysis for the production in a biotechnological company. Skills • can establish a plant description, process diagrams, mass balances and energy balance of a biotechnological production. • can calculate a budget for the establishment and operation of a biotechnological production. • can evaluate the sustainability of the biotechnological production by means of a life-cycle analysis. Competences • can use the competences gained during the education to establish a complete business plan of a sustainable biotechnological company. • can participate in team-based project work • can communicate a project • can reflect upon and develop own learning processes.
Teaching form	Project work

Duration ECTS	15
Content	In the project, a biotechnological company is projected and process diagrams, plant description, mass balances and energy balance is established. The processes in the plant are described with respect to substrates, organisms and processes and a budget for establishment and operation of the company is produced. Also a life-cycle analysis for the production is made. During the course an introduction to business plans and budgeting is given.
Assessment	External oral exam based upon the project report and the presentation of the project.
Grade	7-point scale
Evaluation criteria	As stated in the framework provisions.

3.8.5 Development of recombinant biocatalysts

Dansk titel **English titel**	**Udvikling af rekombinante biokatalysatorer** **Development of Recombinant Biocatalysts**
Placement	Autumn
Prerequisites	Genetics and Molecular Biology, Applied Microbiological Diversity
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.
Evaluation criteria	As stated in the framework provisions.

3.9 6. semester

3.9.1 Biotechnology, Ethics and Society

Dansk titel **English titel**	**Bioteknologi, etik og samfund** **Biotechnology, Ethics and Society**
Placement	Spring
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 framework provisions.
Grade	Pass/fail

3.9.2 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	• 15 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 framework provisions.

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, 2014.

Students who wish to complete their studies under the former study regulations from 2011 must conclude their education by the summer examination period 2016 at the latest, since examinations under the former study regulations are not offered after this time.

In accordance with the Framework Provisions and the Handbook on Quality Management for the Faculties of Engineering, Science and Medicine at Aalborg University, the study regulations must be revised 5 years at the latest after their taking effect.

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 Framework Provisions 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.

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 Framework Provisions 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.