The Faculty of Engineering and Science
The Study Board for Mathematics, Physics and Nanotechnology

Curriculum for the Master's program in Nanobiotechnology

Aalborg University
September 2016

Campus Aalborg

Preface
Pursuant to Act 261 of March 18, 2015 on Universities (the University Act) with subsequent changes, the following curriculum for the Master's program in Nanotechnology is stipulated. The program also follows the Joint programme regulations and the Examination Policies and Procedures for the Faculty of Engineering and Science.

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Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in ministerial orders

The Master's program in Nanobiotechnology is organised in accordance with the Ministry of Science, Technology and Innovation's Ministerial Order no. 1520 of December 16, 2013 on Bachelor's and Master's Programs at Universities (the Ministerial Order of the Study Programs) and Ministerial Order no. 670 of June 19, 2014 on University Examinations (the Examination Order) with subsequent changes. Further reference is made to Ministerial Order no. 258 of March 18, 2015 (the Admission Order) and Ministerial Order no. 114 of February 3, 2015 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation

The Master's program falls under the Faculty of Engineering and Science, Aalborg University.

1.3 Board of Studies affiliation

The Master's program falls under the Board of Studies for Mathematics, Physics, and Nanotechnology under the School of Science and Engineering.

1.4 External Evaluation

The Master's program is associated with the external evaluator corps for Physics and Astronomy.

Chapter 2: Admission, Degree Designation, Program Duration and Competence Profile

2.1 Admission

Applicants with a legal claim to admission (retskrav):
Applicants with one of the following degrees are entitled to admission:

- Bachelor of Science in Nanotechnology, Aalborg University
- Bachelor of Engineering in Nanotechnology, Aalborg University

Applicants without legal claim to admission:
Students with another Bachelor degree may, upon application to the Board of Studies, be admitted following a specific academic assessment if the applicant is considered as having comparable educational prerequisites. The University can stipulate requirements concerning conducting additional exams prior to the start of study.

2.2 Degree designation in Danish and English

The Master's program in Nanobiotechnology entitles the graduate to the designation civilingeniør, cand.polyt.(candidatus/candidate polytechnices) i nanobioteknologi.The English designation is: Master of Science (MSc) in Engineering (Nanobiotechnology).

2.3 The program's specification in ECTS credits

The Master's program is a 2-year, research-based, full-time study program. The program is set to 120 ECTS credits.

2.4 Competence profile on the diploma

The following competence profile will appear on the diploma:

> A graduate of the Master's program has competencies acquired through an educational program that has taken place in a research environment.
>
> The graduate of the Master's program can perform highly qualified functions on the labor market on the basis of the educational program. Moreover, the graduate has prerequisites for research (a Ph.D. program). Compared to the Bachelor's degree, the graduate of the Master's program has developed her/his academic knowledge and independence, so that the graduate can independently apply scientific theory and method in both an academic and occupational/professional context.

2.5 Competence profile of the program:

Students graduating with a degree in Nanobiotechnology have acquired the following knowledge, skills and competencies:

Knowledge	• has knowledge in the major areas within nanobiotechnology that covers advanced gene technology, reaction engineering, high throughput systems, molecular electronics, molecular simulations, self-assembling systems, reaction at interfaces, and spectroscopic methods such as MS and NMR • can understand and reflects over theory, methods and experiments within the mentioned areas
Skills	• should be able to apply up-to-date methods to describe and solve problems on a scientific level within nanobiotechnology • can evaluate problems and select among the scientific theories, methods, tools and general skills within the mentioned areas in order to find a solution based on a scientific analyses • can communicate research-based knowledge and discuss professional and scientific problems with both peers and non-specialists
Competencies	• can manage work and development situations that are complex, unpredictable and require new solutions • can independently initiate and implement discipline-specific and interdisciplinary cooperation and assume professional responsibility • can independently take responsibility for own professional development and specialization

Chapter 3: Content and Organisation of the Program

The program is structured in modules and organised 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 that are defined in the curriculum.

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

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

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 by assessment by the supervisor only).

Overview of the Master's program in Nanobiotechnology:

Semester	Code	Module	ECTS	Assessment	Exam
1	NB1-1	Nanobioengineering	15	7-point scale	Internal
	NB1-2	Advanced Gene Technology	5	7-point scale	Internal
	NB1-3	Reaction Engineering and Molecular Electronics	5	7-point scale	Internal
	NB1-4	Molecular Simulations	5	Pass/fail	Internal
2	NB2-1	Characterisation of Nanobiostructures	15	7-point scale	External
	NB2-2	Self-assembling Systems	5	Pass/fail	Internal
	NB2-3	Reactions at Interfaces	5	7-point scale	Internal
	NB2-4	NMR and MS	5	7-point scale	Internal
3**	NB3-1	Advanced Nanobiotechnology*	30	Pass/fail	Internal
4	NB4-1	Master's Thesis	30	7-point scale	External

* 10 ECTS of the project module Advanced Nanobiotechnology can be replaced by other elective modules offered by the school or university.

**cf. Joint programme regulationsJoint programme regulations 2.3, students are also given the choice of composing an individual planned semester, including extending the master's thesis to up to 60 ECTS if the thesis includes experimental work. The student can also go abroad, take modules at another Danish university, or complete the project in collaboration with or at a company. All these options require an application and approval by the board of studies. The approval should happen before the semester starts.

3.0 Course in Problem Based Learning and Student Responsibilities at Aalborg University

Title:
Problem Based Learning and Student Responsibilities at Aalborg University

Prerequisites:
None, but the course is compulsory for students not acquainted to the Aalborg PBL model

Objective:
Students who complete the module should:
Knowledge:

- Have knowledge about the organization at Aalborg university and where to get help in different matters
- Have knowledge about how to communicate both in your project groups but also when attending courses
- Have comprehension for how a semester is structured and about the different examination forms we use at Aalborg University
- Have comprehension for how project work and laboratory work is carried out at Aalborg University including safety issues in the laboratory
- Have comprehension for issues concerning plagiarism and the consequence when doing plagiarism
- Have knowledge about the software which are used in the study
- Have knowledge about the IT systems used and how to get started
- Have knowledge about the students counselor and what they can do

Skills:

- Be able to use problem based learning and perform group work when doing projects and courses at Aalborg University
- Be able to use Moodle i. e. for finding lecture plans, time schedules etc.

Competences

- Be able to apply the concepts, theories and methods for problem based learning and group work
- Be able to account for the considerations involved in the process of formulating project reports in practice.

Type of instruction:
Lectures, discussions and group work. The course will take place on Wednesday afternoons.

Form of examination:
Internal assessment during the course/class participation according to the rules in the Examination Policies and Procedures, Addendum to the Framework Provision of Faculty of Engineering and Science, Aalborg University. In this case the assessment is primarily based on the oral performance during the course, this means that the student has to be active during the course time and participate

in discussions. The course is an integrated part of the project for those not acquainted to the Aalborg PBL model, and is a precondition for participation in the project examination. In this way there will be no diploma for the course and it will not be visible on the academic transcripts.

Evaluation criteria:
Passed/not passed as stated in the Framework Provisions

3.1. Description of modules for 1st semester, NB1

3.1.1 Project module on 1st semester, NB1

Title: Nanobioengineering/Nanobioengineering.

The project is designed to cover a broad range of topics. It can be a theoretical or an experimental project dealing with all aspects relevant for manufacturing and engineering of biological/organic nanostructures.

Objective: Students who complete the module:

Knowledge

- must have knowledge about how to design, model and manufacture different biological/organic nanostructures
- must be able to understand the fundamental concepts of engineering and design of nanostructures based on organic/biological systems

Skills

- must be able to apply the design, engineering and manufacturing concepts in order to predict and fabricate the desired organic or bio-nanostructures
- must be able to evaluate the different methods used for production, design, and engineering of nanobiostructures

Competencies

- must have obtained the skills to design, model, fabricate and characterize nano-scale (bio)structures

Type of instruction: Supervised project work done in groups.

Exam format: Individual oral evaluation based on project report.

Evaluation criteria: Are stated in the Joint programme regulations.

3.1.2 Course modules on 1st semester, NB1

NB1-2: Course module Advanced Gene Technology/Avanceret genteknologi.

Prerequisites: The module builds on knowledge obtained by the module Gene technology on 5th semester of the bachelor nanotechnology or similar basis knowledge in gene technology.

Objective: Students who complete the module:

Knowledge:

- Must have knowledge about advanced gene expression systems
- Must have knowledge about high throughput screening methods
- Must have knowledge about advanced applications of gene technology in the areas of biotechnology, medicine, and nanotechnology

Skills:

- Must be able to apply the knowledge to solve real world problems
- Must be able to understand the principles
- Must be able to engineer (theoretically) new DNA based nano-devices

Competencies:

- Must have a deeper understanding of the principles and tools
- Must know how to engineer nano-devices for applications in the area of medicine and biotechnology

Type of Instruction: Lectures with problems.

Exam format: Individual written or oral evaluation.

Evaluation criteria: Are stated in the Joint programme regulations.

NB1-3: Course module Reaction Engineering and Molecular Electronics/Engineering af reaktioner og molekylær elektronik.

Prerequisites: The module builds on knowledge in the area of physical chemistry, statistical mechanics, Inorganic and Organic Chemistry, Lab-on-a-Chip, Quantum Mechanics, and Microbiology.

Objective: Students who complete the module:

Knowledge:

- Must acquire knowledge about basic design principles and modeling of chemical, biochemical, and biotechnological reactors
- Must acquire knowledge about micro-reactors and their application in biotechnology
- Must acquire knowledge on the underlying principles and the current state of molecular electronics

Skills:

- Must be able to apply the acquired knowledge to the design and performance evaluation of batch and continuous flow reactors
- Must be able to model chemical and biochemical reactors using COMSOL and other mathematical modeling software

Competencies:

- Must have working knowledge and basic skills for designing, modeling and evaluating of chemical, biochemical, and biotechnological reactors
- Must acquire an overview of the current progress in the area of molecular electronics

Type of instruction: Lectures and exercises.

Exam format: Individual oral evaluation.

Evaluation criteria: Besides the evaluation criteria stated in the Joint programme regulations, the grade requires participation in presentations and discussions of research papers and completion of an assignment.

NB1-4: Course module Molecular Simulations/Molekylær simulering.

Prerequisites: The module builds on knowledge in the area of Organic chemistry, Protein Physics, Quantum Mechanics, statistical mechanics, and physical chemistry.

Objective: Students who complete the module: will have gained skills in the up to date computer modeling techniques of molecular dynamics and analysis of in silico modeled protein, peptide and membrane structures and function.

Knowledge:

- Must have knowledge about modern force fields
- Must have knowledge about protein folding and function
- Must have knowledge about the general building blocks of proteins and their chemistry
- Must be able to evaluate protein structures
- Must be able to apply the principals of protein structures and functions to real problems

Skills:

- Must be able to apply principals of Molecular dynamics simulations to real problems
- Must be able to evaluate modeled protein structures and function
- Must be able to apply the properties and chemistry of the aminoacids to real world problems
- Must be able to evaluate results from molecular dynamics simulations

Competencies:

- Must have a basic understanding of molecular modelling
- Must have a general understanding of the physics of protein dynamics and force field based modeling strategies
- Must have a general knowledge molecular simulations

Type of instruction: Lectures with accompanying problem solving session.

Exam format: Individual continuous evaluation based on active participation.

Evaluation criteria: Are stated in the Joint programme regulations.

3.2 Description of modules for 2nd semester, NB2

3.2.1 Project on 2nd semester, NB2

Title: Characterisation of Nanobiostructures/Karakterisering af nanobiostrukturer.

Prerequisites: The module builds on knowledge obtained by the project on NB1 (1st semester).

The project is designed to cover a broad range of topics. It can be a rather more theoretical or experimental project dealing with all aspects relevant for manufacturing and characterization of biological/organic nanostructures.

Objective: Students who complete the module:

Knowledge:

- Must have knowledge about methods and tools used for production and characterization of biological/organic nanostructures
- Must be able to understand the fundamental concepts behind the methods and tools used for production and characterization of biological/organic nanostructures

Skills:

- Must be able to produce biological/organic nanostructures and must be able to investigate their properties by using different methods and tools
- Must be able to evaluate the different methods used for production and characterization of nano(bio)structures

Competencies:

- Must have obtained the skills to produce and characterize biological/organic nanostructures by using different tools

Type of instruction: Supervised project work done in groups.

Exam format: Individual oral evaluation based on project report.

Evaluation criteria: Are stated in the Joint programme regulations.

3.2.2 Courses on 2nd semester, NB2

NB2-2: Course module Self-Assembling Systems/Selvorganiserende biostrukturer.

Prerequisites: The module builds on knowledge in the area of Statistical Mechanics, physical chemistry, Inorganic and Organic Chemistry, and biochemistry.

Objective: Students who complete the module:

Knowledge:

- Must acquire knowledge about basic principles of self-assmbling behavior in nature, forces involved in the process, ways to model and design a self-assembling system
- Must acquire knowledge about application of self-assembly for drug-delivery, thin films and nano-arrays

Skills:

- Must be able to use Langmuir-Blodgett technique as well as other methods to fabricate monolayers, micelles and vesicles
- Must be able to apply the acquired knowledge to critically read and understand research papers on the subject of self-assembly

Competencies:

- Must acquire an overview of the current progress in the areas of self-assembly and drug delivery

Type of instruction: Lectures and exercises.

Exam format: Individual oral or written evaluation.

Evaluation criteria: Are stated in the Joint programme regulations.

NB2-3: Course module Reactions at Interfaces/Reaktioner på grænseflader.

Prerequisites: The module builds on knowledge in the area of Statistical Mechanics, physical chemistry, Inorganic and Organic Chemistry.

Objective: Students who complete the module:

Knowledge:

- Must acquire knowledge about basic thermodynamics and kinetics of surface processes including phenomena of surface tension, wetting and adsorption
- Must acquire knowledge about major interaction forces near the interfaces including van der Waals and double-layer forces
- Must acquire knowledge about structure of the surface and adsorbate layers

Skills:

- Must be able to apply the knowledge to the issues of colloidal stability, micelle and monolayer formation and electrokinetic phenomena
- Must be able to apply the acquired knowledge to critically read and understand research papers on the subject

Competencies:

- Must acquire an overview of basic phenomena involved in the interactions at interfaces, understand forces governing interactions on nanoscale, be able to deal with issues involving colloidal particles, surfactants, micelles and other important nano-sized objects

Type of instruction: Lectures and exercises.

Exam format: Individual Oral evaluation.

Evaluation criteria: grade Besides the evaluation criteria stated in the Joint programme regulations, the requires completion of an assignment.

NB2-4: Course module NMR and MS/NMR og MS.

Prerequisites: The module builds on knowledge in the area of organic and physical chemistry.

Objective: Students who complete the module:

Knowledge

- should have knowledge about the theoretical background of NMR and MS, especially about how to get signals and interpretation of signals
- should have knowledge about the experimental process how NMR and MS data are collected

Skills

- should be able to interpret 1D and 2D NMR spectra which means to be able to predict a spectrum from a given structure, find an unknown structure based on a given spectrum or be able to assign NMR signals to atoms within a structure
- should be able to evaluate applications for NMR and MS for chemical/biotechnological/nanotechnological problems
- should be able to interpret MALDI MS and ESI MS spectra
- should be able to use correct concept, nomenclature, and symbols from the NMR and MS literature

Type of instruction: Lectures with problems.

Contents: The following topics are part of that module:

NMR:
The physical background for NMR: Nuclear spin, spin in a magnetic field, CW-NMR, FT-NMR, radiofrequency pulses; Spectral parameters: chemical shift, scalar and dipolar coupling; Spectroscopic technique: 1D experiments with one or more pulses; Experimental aspects: construction of NMR spectrometer, experimental NMR, signal treatment, Nuclear Magnetic Relaxation: spin-lattice or spin-spin relaxation and their dependence on molecular mobility, nuclear Overhauser effect; 2D-NMR: meaning of 'chemical shift labeling', magnetization transfer between spins, acquisition of the indirect dimension, homonuclear 2D-NMR (COSY, TOCSY, NOESY), heteronuclear 2D-NMR (HSQC, HMQC); Dynamic NMR Spectroscopy: chemical shift, lineshape analysis, 'coalescence', timescale for NMR; Interpretation of NMR spectra: assignment of signals, structure determination of small molecules; selected topics of modern, applied NMR, i.e.: NMR of macromolecules, 'magnetic resonance imaging', description of NMR based on quantum mechanics, metabolic profiling via NMR; Problems: Interpretation of spectra, identification of compounds based on their spectra, collecting data on the in-house spectrometer, theoretical calculations.

MS:
History of MS development and applications within biotechnology and chemistry, physical concept behind MS ionization (matrix-assisted laser desorption ionization/electro-spray); mass analyzer (time-of flight, quadrupol, ion-field). MS/MS sequencing, iondetection, reflectron. Application of on-line chromatography (HPLC, GC, CE). Special applications for different MS, i.e. MALDI-TOF-MS and nano-spray followed by MS/MS for analysis of proteins. Interpretation of spectra of organic molecules (proteins, peptides and DNA sequences, carbohydrates) and problems to support the theory behind it. Introduction to mass spectrometry based bioinformatics.

Exam format: Individual written or oral evaluation.

Evaluation criteria: Are stated in the Joint programme regulations.

3.3 Description of modules for 3rd semester, NB3

3.3.1 Project on 3rd semester, NB3

Title: Advanced Nanobiotechnology/Avanceret Nanobioteknologi.

Prerequisite: The module builds on knowledge obtained by the project on NB2 (2nd semester).

This project focuses on all kinds of advanced biostructures and their static and dynamic properties. It is considered as the first half of the master thesis if the thesis has experimental character. Project exam is considered as the mid-term evaluation of the Master's thesis, where the students present their obtained results as well as a plan for the second part of the thesis. In case of a purely theoretical work, this project is considered as a normal semester project. This semester should give students the possibility to either go abroad or to work in collaboration with other Danish institutions/companies as part of their master thesis.

Competence:

- should be able to identify, formulate, and analyze independently a problem
- should have the necessary skills to identify and apply the relevant scientific theories and methods to the formulated problem

Contents: Different advanced nanobiostructures will be manufactured and their static and dynamic properties will be characterized using state-of-the-art scientific tools, techniques and theories.

Exam format: Individual oral evaluation based on project report.

Evaluation criteria: Are stated in the Joint programme regulations.

3.4 Description of modules for 4th semester, NB4

3.4.1 Project module on 4th semester, NB4

Title: Master's Thesis/Kandidatspeciale.

Prerequisite: The module builds on knowledge obtained by the project on NB3 (3rd semester).

The project can cover the same topic as the 3rd semester project and should be approved by the Board of Studies.

The student should have the following knowledge, skills and competence:

Knowledge:

- Knowledge of the subject-specific methods as well as tools applied for the design, fabrication, characterization, and modeling of the biological and organic nanostructures described in the thesis
- Knowledge of the biological, physical, and (bio)chemical principles behind the subject of the thesis

Skills:

- Ability to approach, describe, and solve a specific problem using the tools available
- Ability to explore and achieve sufficient understanding of the state-of-the-art within the area of the thesis subject
- Ability to define the limits of the project
- Ability to demonstrate scientific and professional project work
- Ability to reflect over the obtained results

Competence:

- Applying the knowledge and skills obtained during the master program to solve the subject specific problem of the thesis with the support of the supervisor
- Evaluate the approach, methods, and materials used for the project to fulfill the goal of the project
- Be able to relate the problem to the relevant field/area and the obtained results
- Be able to make and justify decisions on the relevant theories and methods

Exam format: Individual oral evaluation based on project report.

Evaluation criteria: Are stated in the Joint programme regulations

Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of the Faculty of Engineering and Science and enters into force as of 1st of September 2016.

Students who wish to complete their studies under the previous curriculum from 2013 must conclude their education by the summer examination period 2017 at the latest, since examinations under the previous curriculum are not offered after this time.

Chapter 5: Other Provisions

5.1 Rules concerning written work, including the Master's thesis

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 formulation ability, in addition to the academic content. 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 language performance alone; similarly, an examination normally cannot be assessed as 'Fail' on the basis of poor language performance alone.
The Board of Studies can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Master's thesis must include an English summary.[1] If the project is written in English, the summary must be in Danish.[2] The summary must be at least 1 page and not more than 2 pages. The summary is included in the evaluation of the project as a whole.

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 Board of Studies can approve successfully completed (passed) program elements from other Master's programs in lieu of program elements in this program (credit transfer). The Board of Studies 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 Board of Studies based on an academic assessment. See the Joint programme regulations for the rules on credit transfer.

5.3 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.

5.4 Exemption

In exceptional circumstances, the Board of Studies study 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.

[1] Or another foreign language (upon approval from the Board of Studies.
[2] The Board of Studies can grant exemption from this.

5.5 Completion of the Master's program

The Master's program must be completed no later than four years after it was begun.

5.6 Rules and Requirements concerning the Reading of Texts in Foreign Languages and a Statement of the Foreign Language Knowledge

It is assumed that the student is able to read academic texts in English and uses reference works, etc., in other European languages.

5.7 Additional information

The current version of the curriculum is published on the Board of Studies' website, including more detailed information about the program, including exams.