STUDY REGULATION for **Mathematical Bioscience**

CAND.SCIENT.

Version: 11

Valid per 1 september 2022

ROSKILDE UNIVERSITY

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1. Study Regulation

1.1 The programme's name

Master programme in Mathematical Bioscience

1.2 Scope of the regulation

This study regulation is determined pursuant to The University Programme Order No. 2285 of 1 December 2021 on Bachelor and Master's (Candidatus) Programmes at Universities with any subsequent amendments and Roskilde University's common education regulations of 1 September 2022 with any subsequent amendments. The study regulation will become effective on 1 September 2022 and applies to all students.

Rules and Regulations concerning registration and de-registration for courses, projects, thesis and examination and regulations concerning start-of-studies examination, dispensations, mobility, credit transfer and pre-approval of credit transfer are specified in RUC´s common education regulations.

1.3 Title

Graduates of the programme are awarded with the degree: Master of Science (MSc) in Mathematical Bioscience
Graduates of the programme are awarded with the Danish title: cand.scient. i Matematisk biovidenskab

2. The programme's objective, employment and competency profile

2.1 Objective

The overall objective of the programme is to provide the candidate with the necessary biological and mathematical knowledge, understanding, skills and competencies to analyse complex biological data as well as to develop and implement mathematical models of biological systems.

2.2 Employment

The programme has been designed to give the graduates qualifications and competencies to work within research, development, and consulting, where mathematical modelling and scientific data analysis of, for example, large complex biological data, play the principal role. Work areas include the bio-chemical and biotech industry, the healthcare sector, financial sector, public research institutions and administration.

2.3 Competency profile

Through problem-oriented project learning and interdisciplinary problem solving the candidate will obtain the necessary biological and mathematical competencies and skills to critically analyse, understand, and present complex biological data as well as to develop and implement mathematical models of biological systems. The programme is partly based on student-driven explorations of biological systems; this gives the candidate a solid foundation to independently investigate general complex systems. Finally, the candidate will be able to discuss, reflect on, and communicate results from both biology and mathematics.

Knowledge and understanding

Following the completion of the Master's degree in Mathematical Bioscience, the candidate will be able to

- possess an in-depth understanding of specific areas in advanced biology and mathematics

- critically reflect on, evaluate, and apply different methodologies used in biology and mathematics
- argue and reflect on how models can contribute to gain fundamental new knowledge about biological systems and processes, and how the models can be applied to predict, optimize and control these systems and processes
- demonstrate and apply knowledge of international leading and relevant biological and mathematical literature to support the solutions to advanced challenges
- independently initiate, organize and structure analysis and design models in natural science
- address research questions in a problem-oriented fashion

Skills

Following the completion of the Master's degree in Mathematical Bioscience, the candidate will be able to

- analyse, structure, and categorize large and complex biological data sets statistically using digital tools
- analyse complex data and formulate biological hypotheses and conjectures based on this analysis
- analyse, implement, and develop mechanism-based mathematical models of biological systems and processes
- perform model parameter estimation and critically evaluate these parameters in context of the specific biological research question
- independently code and revise programs to numerically solve complex mathematical models
- communicate in a clear and concise multi-disciplinary manner, specifically, communicate mathematical results to biologists and biological results to mathematicians

Competencies

Following the completion of the Master's degree in Mathematical Bioscience, the candidate will be able to

- build bridges, facilitate collaboration, and exchange knowledge between biologists and mathematicians, as well as communicate in an interdisciplinary environment
- construct, support, and participate in multi and inter-disciplinary research and development teams
- develop and design new mathematical models testing biological hypotheses
- produce relevant presentation of data and model results in the academic language appropriate to the broad fields of biology and mathematics, written as well as verbally
- independently design, develop, and test mathematical models of biological systems on the background of data analysis
- take responsibility for own professional development and specialisation within specific areas of the disciplines

3. Language

The programme is offered in English.

The examination language is identical to the teaching language.

4. Admission requirements

The Board of Studies specifies the admission requirements following the Ministerial Order on Admission to and Enrolment on Master's Degree Programmes at Universities.
On the university's website, the admission requirements are published as an appendix to the study regulation.
Changes in admission requirements are announced at least one year before the commencement of studies.

5. ECTS rating and duration

The programme is a full-time programme corresponding to 120 ECTS and planned in preparation for a two years full-time study.

6. Board of Studies, Corps of External Examiners and Main area affiliation

6.1 Board of Studies

The programme falls under Board of Studies for Natural Sciences

6.2 Corps of External Examiners

The programme falls under Mathematics

6.3 Main area affiliation

The programme falls under the main subject area natural sciences

7. The programme's structure

7.1 Schematic structure of the programme

<table>
<tr><td>4 semester</td><td colspan="5">Master Thesis
(30 ECTS)</td></tr>
<tr><td>3 semester</td><td>Parameter Estimation
(5 ECTS)</td><td>Differential Geometry
(5 ECTS)</td><td>Pharmacology
(5 ECTS)</td><td colspan="2">Specialization Project / Project-oriented Internship
(15 ECTS)</td></tr>
<tr><td>2 semester</td><td>Dynamical Systems Analysis
(5 ECTS)</td><td>Probability and Statistics
(5 ECTS)</td><td>Advanced Eukayotic Cell Biology I
(5 ECTS)</td><td>Fundamental Mathematical Structures / Scientific Computing and Data Science
(10 ECTS)</td><td>Biology Elective Course
(5 ECTS)</td></tr>
<tr><td>1 semester</td><td colspan="2">Modelling of Biological Systems
(10 ECTS)</td><td>Biology Elective Course / General Molecular and Medical Biology (5 ECTS)</td><td colspan="2">Modelling Project
(15 ECTS)</td></tr>
</table>

7.2 First semester

Objective

The overall objective is to give an introduction to mathematical modelling of biological systems. In the course 'Modelling of biological systems' standard models are analysed mathematically and one basis of the underlying biological mechanisms. The modelling and analysis competencies are trained further in the semester project. Students with no biological background is advised to follow the course Foundation Course in Biology.

Study activities
Mandatory study activities (total of 25 ECTS)

- Modelling of Biological Systems (10 ECTS)
- Modelling Project (15 ECTS)

Elective study activities (total of 5 ECTS)

- General Molecular and Medical Biology (5 ECTS)
- Biology Elective Course (5 ECTS)

Each semester, the board of studies approves a number of biology courses from Molecular Health Science, Chemical Biology or Environmental Science for students to choose from.

Students who need an introduction course to biology are highly recommended to choose the course in General Molecular and Medical Biology whereas students who have had biology as a part of their bachelor programme can choose either Molecular and Medical Biology or another elective course in the area of biology. The board of studies announces approved and offered courses for each semester.

7.3 Second semester

Objective

The overall objective in this semester is to give the student an understanding of the two different methodologies used in biology and in mathematics. Through the courses 'Advanced eukayrotic cell biology', 'Dynamical system analysis' and 'Probability and Statistics' the student will see examples of the biologist's, the statistician's, and the mathematician's logic, reasoning, formalism, and scientific methodology.

Study activities
Mandatory study activities (total of 25 ECTS)

- Dynamical Systems Analysis (5 ECTS)
- Probability and Statistics (5 ECTS)
- Advanced Eukaryotic Cell Biology 1 – Inside the Cell (5 ECTS)
- Fundamental Mathematical Structures or Scientific Computing and Data Science (10 ECTS)

Elective study activities (total of 5 ECTS)

- Biology Elective Course (5 ECTS)

Each semester, the board of studies approves a number of biology courses from Molecular Health Science, Chemical Biology or Environmental Science for students to choose from.

7.4 Third semester

Objective

The overall objective in this semester is student specialisation. This is realized through the 15 ECTS specialisation project or the project-oriented internship. Also, the course 'Parameter estimation' focuses on advanced specialised methods in the analysis of model parametrisation. This semester also acts as preparation for the Master thesis semester.

Study activities
Mandatory study activities

- Parameter Estimation (5 ECTS)
- Differential Geometry (5 ECTS)
- Pharmacology (5 ECTS)
- Specialisation Project or Project-oriented Internship (15 ECTS)

7.5 Fourth semester - Master Thesis

Objective

In the master thesis the objective is that the student show the ability to apply the skills, knowledge, and competencies obtained in the programme to independently, formulate a current research question/hypothesis in the field of mathematical bioscience. The student can investigate the problem by, for example, perform laboratory experiments and analyse the data both statistically and through existing models, design new mathematical models based on existing data, and/or formulate novel and original methods to analyse data and models.

Study activities
Mandatory study activities

- Master thesis (30 ECTS)

7.6 Transitional rules

7.7 Overall description of study activities

Study activities

- Modelling of Biological Systems (10 ECTS)
- Modelling project (15 ECTS)
- General Molecular and Medical Biology (5 ECTS)
- Dynamical Systems Analysis (5 ECTS)
- Probability and Statistics (5 ECTS)
- Advanced Eukaryotic Cell Biology 1 – Inside the Cell (5 ECTS)
- Fundamental Mathematical Structures (10 ECTS)
- Scientific Computing and Data Science (10 ECTS)
- Parameter Estimation (5 ECTS)
- Differential Geometry (5 ECTS)
- Pharmacology (5 ECTS)
- Specialisation Project (15 ECTS)
- Project-Oriented Internship (15 ECTS)
- Master Thesis (30 ECTS)

Title	**Modelling of Biological Systems**
Type of activity	Course

Mandatory or elective	Mandatory
ECTS-rating	10 ECTS
Teaching language	English
Overall objective	The overall objective of the course is to give the student a fundamental understanding of and experience with modelling biological systems using mathematics and what is achieved by this.
Overall learning outcomes	After the course the student will be able to • discuss and apply classic mechanism-based mathematical models of selected areas within biology, for example, populations, epidemics, disease spreading in the human body, and competition. • apply the modelling cycle in order to develop mathematical models of biological systems from experimental data. • reflect on and argue how modelling is used to gain fundamental new biological insight through model analysis. • reflect on and argue how the models can be used to predict and control biological systems and processes. • critically and analytically explore the limitations and validity of different models. • perform numerical explorations of the mathematical models using relevant programme language(s) like e.g. Python
Type of exam	**Type of exam** Individual written invigilated exam. The duration of the exam is 4 hours. Permitted support and preparation materials for the exam: All. Assessment: 7-point grading scale. Moderation: External examiner. **Reexam** Individual oral exam with time for preparation. Time for preparation including time to pick a question by drawing lots: 45 minutes. Time allowed for exam including time used for assessment: 45 minutes. Permitted support and preparation materials: Course material and own notes.

	Assessment: 7-point grading scale. Moderation: External examiner. Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Modelling project**
Type of activity	Project
Mandatory or elective	Mandatory
ECTS-rating	15 ECTS
Teaching language	English
Overall objective	The overall purpose of the modelling project is that the student develop/ design or analyse existing mathematical models of an exemplary biological system through problem-oriented project work.
Overall learning outcomes	After this activity the student will be able to • perform descriptive statistics of biological data-sets. • demonstrate state-of-art knowledge about the specific biological system behind the data. • demonstrate knowledge of previous mathematical model(s) describing the biological system. • demonstrate an in-depth analytical/numerical understanding of one or more mechanism-based models found in the scientific literature or a model developed by the project group. • argue how models can be used to understand the underlying biological processes and how models can be used as predictive tools. • seek relevant literature, formulate research problems/ hypotheses, work in a problem-oriented fashion, and conclude on the project research question.
Type of exam	**Type of exam** Oral project exam in groups with individual assessment. Permitted group size: 2-7 students. The character limits of the project report are: For 2 students: 24,000-307,200 characters, including spaces. For 3 students: 24,000-307,200 characters, including spaces. For 4 students: 24,000-307,200 characters, including spaces.

	For 5 students: 24,000-307,200 characters, including spaces. For 6 students: 24,000-307,200 characters, including spaces. For 7 students: 24,000-307,200 characters, including spaces. The character limits include the cover, table of contents, summary, bibliography, figures and other illustrations, but exclude any appendices. The project report must include a summary in English, that is part of the assessment. Time allowed for exam including time used for assessment is for: 2 students: 60 minutes. 3 students: 75 minutes. 4 students: 90 minutes. 5 students: 105 minutes. 6 students: 120 minutes. 7 students: 135 minutes. Writing and spelling skills in the project report are part of the assessment. Permitted support and preparation materials at the oral exam: All Assessment: 7-point grading scale. Moderation: Internal co-assessor. Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**General Molecular and Medical Biology**
Type of activity	Course
Mandatory or elective	Mandatory/Elective Mandatory: Chemical Biology - Track 1 and Molecular Health Science - Track 1 Elective: Mathematical Bioscience
ECTS-rating	5 ECTS
Teaching language	English
Overall objective	The aim of the course is to prepare students, without basic knowledge in several of these topics: molecular biology, cell biology, microbiology, genetics, biochemistry, human physiology and anatomy, to enable them following Masters' courses offered by Molecular Health Science and other related Masters' programmes. This is course containing specific

	elements of cell biology, molecular biology, microbiology, biochemistry and physiology, knowledge of which is required for further studies.
Overall learning outcomes	After completing the course, the students will be able to: • describe and discuss the macromolecules and organisation of the eukaryotic cells • identify and interpret different types of signaling between cells in an organism • describe and discuss the principles of the central dogma (transcription-translation) and cell division (DNA-repair, mutations, tumors, cancer) • interpret data of common methods in molecular biology (western blot, (q)PCR, sequencing, microscopy) • describe and explain basic biochemistry (simple intracellular metabolism, i.e. glycolysis, tricarboxylic acid cycle, oxphos) and enzyme kinetics and reaction kinetics in general • describe and discuss the biology of virus and bacteria, including particle or cellular structures • identify and interpret the principles of population growth in relation to microbiology or environmental biology • describe and discuss basic physiology, especially cardiovascular and renal physiology, as well as absorption and digestion of nutrients & intermediary metabolism • describe and explain inflammation & the immune system.
Type of exam	**Type of exam** Individual oral exam without time for preparation. Time allowed for exam including time used for assessment: 15 minutes. Permitted support and preparation materials: None. Assessment: Pass/Fail. Moderation: Internal co-assessor. Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Dynamical Systems Analysis**
Type of activity	Course
Mandatory or elective	Mandatory Physics and Scientific Modelling - General Profile: a choice between Differential Equations in Models and Dynamical Systems Analysis.

ECTS-rating	5 ECTS
Teaching language	English
Overall objective	The overall objective of the course is to give the student an advanced understanding dynamical systems and how analysis of these are constructed.
Overall learning outcomes	After the course the student will be able to • formulate mathematical analysis of non-linear differential equation systems, e.g., via phase plane analysis. • perform local and global stability analysis. • demonstrate in-depth knowledge about bifurcations and how these affect the dynamics in mathematical models. • present results from the mathematical analysis in a clear and concise manner using mathematical formalism and reasoning. • critically assess the mathematical methodology behind analysis of dynamical systems analysis
Type of exam	**Type of exam** Individual oral exam based on a portfolio. The character limit of the portfolio is 1,200-120,000 characters, including spaces. Examples of written products are exercise responses, talking points for presentations, written feedback, reflections, written assignments. The preparation of the products may be subject to time limits. The character limits include the cover, table of contents, bibliography, figures and other illustrations, but exclude any appendices. Time allowed for exam including time used for assessment: 30 minutes. The assessment is an assessment of the oral examination. The written product(s) is not part of the assessment. Permitted support and preparation materials for the oral exam: All. Assessment: 7-point grading scale. Moderation: Internal co-assessor Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Probability and Statistics**
Type of activity	Course

Mandatory or elective	Mandatory Mandatory: Mathematical Bioscience and Physics and Scientific Modelling - Thematic profile 1 and 2 Elective: Physics and Scientific Modelling - General profile
ECTS-rating	5 ECTS
Teaching language	English
Overall objective	The overall objective of the course in Probability and Statistics is to endow the student with a fundamental understanding of how the mathematical theory of probability and statistics is constructed, enabling the student to critically reflect on how statistical analysis of data is applied.
Overall learning outcomes	After the course the student will be able to • compute with and understand the theory behind probability distributions, and model random phenomena using probability theory, stochastic variables and mathematical reasoning, • apply parametric statistics to data, in particular in formulating hypotheses, assessing estimators, computing test probabilities and interpreting the results using mathematical and statistical reasoning, • apply digital tools for statistical investigations, model simulation, and analysis, • describe and explain the mathematical structure of probability theory, • demonstrate in-depth understanding of how parametric statistics is built upon probability theory. • analyse, evaluate and formulate models of stochastic phenomena using mathematical and statistical reasoning. • present stochastic and statistical theories and methods in a clear and concise manner using mathematical formalism
Type of exam	**Type of exam** Individual oral exam without time for preparation. Time allowed for exam including time used for assessment: 30 minutes. Permitted support and preparation materials: All. Assessment: 7-point grading scale. Moderation: Internal co-assessor. Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	Advanced Eukaryotic Cell Biology 1 – Inside the Cell
Type of activity	Course
Mandatory or elective	Mandatory
ECTS-rating	5 ECTS
Teaching language	English
Overall objective	Theoretical course in eukaryotic cell biology aiming to give the students a broad knowledge and understanding of form and function of cellular compartments and organelles as well as intracellular regulatory mechanisms
Overall learning outcomes	After completing the course, the students will be able to: • explain the organization and function of chromosomes, membranes, organelles and cytoskeleton in the eukaryotic cell • explain the organization, coordination, and regulation of processes in eukaryotic cells, including gene expression, intracellular protein sorting, vesicular traffic and cell signaling • discuss how experiments have contributed to the current principles of cell biology • compare the various functions of proteins in eukaryotic cells such as receptors, transport proteins, ion channels and cytoskeletal proteins • describe, analyze, and evaluate results from cell biology experiments • complete a theoretical review of the latest scientific literature in eukaryotic cell biology • formulate new scientific hypotheses as the starting point for a thesis project in eukaryotic cell biology.
Type of exam	**Type of exam** Individual written invigilated exam. The duration of the exam is 3 hours. Permitted support and preparation materials for the exam: Dictionaries and pocket calculator. Assessment: 7-point grading scale. Moderation: Internal co-assessor. Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	Fundamental Mathematical Structures
Type of activity	Course
Mandatory or elective	Mandatory Physics and Scientific Modelling - Thematic profile 2. Mathematical Bioscience and Physics and Scientific Modelling - General profile: a choice between Fundamental Mathematical Structures and Scientific Computing and Data Science.
ECTS-rating	10 ECTS
Teaching language	English
Overall objective	The overall objective of the course is to give the student an understanding of mathematical structures and proficiency in formulating mathematical logic, reasoning, and argumentation.
Overall learning outcomes	After the course the student will be able to • present concrete mathematical structures in the field of set theory, topology, analysis and algebra • formulate proofs of common features and differences between such structures • exercise mathematical reasoning in relation to the subject • compare and differentiate between different types of mathematical arguments and proofs • critically and independently judge the validity of a mathematical proof
Type of exam	**Type of exam** Individual oral exam based on a portfolio. The character limit of the portfolio is 1,200-120,000 characters, including spaces. Examples of written products are exercise responses, talking points for presentations, written feedback, reflections, written assignments. The preparation of the products may be subject to time limits. The character limits include the cover, table of contents, bibliography, figures and other illustrations, but exclude any appendices. Time allowed for exam including time used for assessment: 30 minutes. The assessment is an assessment of the oral examination. The written product(s) is not part of the assessment. Permitted support and preparation materials for the oral exam: All.

	Assessment: 7-point grading scale. Moderation: Internal co-assessor Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Scientific Computing and Data Science**
Type of activity	Course
Mandatory or elective	Mandatory Physics and Scientific Modelling - Thematic profile 1 and 3. Mathematical Bioscience and Physics and Scientific Modelling - General profile: a choice between Fundamental Mathematical Structures and Scientific Computing and Data Science.
ECTS-rating	10 ECTS
Teaching language	English
Overall objective	To give the student experience in choosing and applying the methods of Scientific Computing and Data Science to new problems and to give the student an overview of methods associated with: • Scientific Computing, i.e., the use of computers and applied math to generate data from models by numerical methods and/or simulation. • Data Science, i.e., the use of computers, models, and applied math to gain insight from data.
Overall learning outcomes	After completing the course the students will be able to • demonstrate an overview of methods in Scientific Computing and Data Science. • choose methods in Scientific Computing and Data Science relevant for a given problem. • independently learn about methods in Scientific Computing and Data Science on an advanced level. • apply methods in Scientific Computing and Data Science to a new problem. This includes the relevant programming, testing, and interpretation of results.
Type of exam	**Type of exam** Individual oral exam based on a portfolio. The character limit of the portfolio is 1,200-120,000 characters, including spaces. Examples of written products are exercise

	responses, talking points for presentations, written feedback, reflections, written assignments. The preparation of the products may be subject to time limits. The character limits include the cover, table of contents, bibliography, figures and other illustrations, but exclude any appendices. Time allowed for exam including time used for assessment: 30 minutes. The assessment is an assessment of the oral examination. The written product(s) is not part of the assessment. Permitted support and preparation materials for the oral exam: All. Assessment: 7-point grading scale. Moderation: Internal co-assessor Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Parameter Estimation**
Type of activity	Course
Mandatory or elective	Mandatory/Elective Mandatory: Mathematical Bioscience. Physics and Scientific Modelling - Thematic profile 1 Elective: Physics and Scientific Modelling - General profile
ECTS-rating	5 ECTS
Teaching language	English
Overall objective	The overall objective of the course is to provide students with a fundamental understanding of selected methods in the field of parameter estimation. Students will learn to apply parameter estimation critically in various biological applications, by working with empirical data and mathematical models.
Overall learning outcomes	The student will be able to • apply singular-value decomposition to big data sets, principal component analysis, and model selection, • critically use the concept of identifiability and evaluate methods to determine parameter identifiability to real world data and models, • critically judge the applicability of various methods for parameter estimation

	• show an overview of selected methods for parameter estimation, and critically and analytically explore the limitations and validity of the methods, • calculate and discuss uncertainty quantification critically. • perform case based numerical explorations using software
Type of exam	**Type of exam** Individual written take-home assignment. The character limit of the assignment is: 1,200-120,000 characters, including spaces. The character limit includes the cover, table of contents, bibliography, figures and other illustrations, but exclude any appendices. The duration of the take-home assignment is 24 hours. Assessment: 7-point grading scale. **Reexam** Individual oral exam without time for preparation. Time allowed for exam including time used for assessment: 30 minutes. Permitted support and preparation materials: Course material and own notes. Assessment: 7-point grading scale. Moderation: Internal co-assessor. Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Differential Geometry**
Type of activity	Course
Mandatory or elective	Mandatory/Elective Mandatory: Mathematical Bioscience. Physics and Scientific Modelling - Thematic profile 2 Elective: Physics and Scientific Modelling - General profile
ECTS-rating	5 ECTS
Teaching language	English

Overall objective	The overall objective of the course in Differential Geometry is to give the student an understanding of its construction and formalism, which enables the student to apply differential geometry in the critical analysis of other mathematical contexts.
Overall learning outcomes	After the course the student will be able to • construct, examine and analyse curves and surfaces in R3. • apply mathematical analysis and linear algebra in differential geometry. • describe the notion and power of chart invariance. • demonstrate in-depth understanding of the relation between manifolds, synthetic differentiability, tangent space, Riemannian metrics and the metric structure of manifolds. • demonstrate in-depth understanding of the relation between ODE's on manifolds and vector fields on manifolds. • operate with concepts and ideas from differential geometry in other mathematical contexts.
Type of exam	**Type of exam** Individual oral exam based on a portfolio. The character limit of the portfolio is 1,200-120,000 characters, including spaces. Examples of written products are exercise responses, talking points for presentations, written feedback, reflections, written assignments. The preparation of the products may be subject to time limits. The character limits include the cover, table of contents, bibliography, figures and other illustrations, but exclude any appendices. Time allowed for exam including time used for assessment: 30 minutes. The assessment is an assessment of the oral examination. The written product(s) is not part of the assessment. Permitted support and preparation materials for the oral exam: All. Assessment: 7-point grading scale. Moderation: Internal co-assessor Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Pharmacology**
Type of activity	Course

Mandatory or elective	Mandatory
ECTS-rating	5 ECTS
Teaching language	English
Overall objective	This is a lecture-based course covering basic pharmacology and as well as the pharmacology of selected treatment areas. Basic pharmacology is introduced, such as receptor-ligand interactions, pharmacokinetics and dynamics, absorption, distribution, metabolism, secretion (ADME), as well as combination effects and adverse reactions. The course also aims to give an introduction to development, clinical testing and registration of pharmacological compounds. The pharmacology of selected areas of treatment is covered, for example cardiovascular pharmacology, renal pharmacology, chemotherapeutics, anti-inflammatory agents, hormones & hormone antagonists.
Overall learning outcomes	After completing the course, the students will be able to: • describe the mechanisms involved in the organisms' handling of foreign substances at different organiza-tional levels (cellular, tissue and organism levels) • explain the interaction of pharmaceuticals and foreign substances with biological membranes, including uptake, mechanism of action and metabolism in the organism as well as various tissue types • compare and discuss the pharmacological basis for treatment of selected, common diseases and describe actions and side effects of pharmacological agents • recall and describe how experiments and clinical studies have contributed to current knowledge and understanding of pharmacology and toxicology • compare the design and analysis of observational studies, clinical testing and experiments in the fields of pharmacology • interpret and evaluate pharmacological experiments, analyses and data in a biological context • conduct theoretical reviews of the latest scientific literature within pharmacology • propose and construct new scientific hypotheses as a starting point for a project related to pharmacology • communicate the knowledge and understanding gained from the course in a precise and scientific way.
Type of exam	**Type of exam** Individual written invigilated exam. The duration of the exam is 3 hours.

	Permitted support and preparation materials for the exam: Dictionaries and non-programmable pocket calculator. Assessment: 7-point grading scale. Moderation: External examiner. **Reexam** Individual oral exam without time for preparation. Time allowed for exam including time used for assessment: 20 minutes. Permitted support and preparation materials: None. Assessment: 7-point grading scale. Moderation: External examiner. Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Specialisation Project**
Type of activity	Project
Mandatory or elective	Elective
ECTS-rating	15 ECTS
Teaching language	English
Overall objective	The overall purpose of the project is that the student specialises in a concrete competence, obtain specific skills, and/or make preparatory studies for the thesis project.
Overall learning outcomes	After the project the student will be able to • demonstrate in-depth knowledge in the history of science in a specific exemplary topic within biology, mathematics, and/or integrated science (reflection variant) OR • demonstrate in-depth knowledge, ability to reflect on and apply one or more specific biological laboratory techniques, specific advanced mathematical analysis methods, and/or highly specialized numerical methods AND/OR • perform critical analysis and reflect on the usage of results from complex/large data set provided by student's own laboratory work or data from the literature AND/OR • perform critical analysis and reflect on the usage of results from one or more mechanism-based mathematical models

	describing a biological system as an example of a general system in natural science. • independently formulate a research problem/hypothesis based on relevant literature, organize, and manage project/group work. • communicate the conclusion from the research question in a clear, concise, and reflected manner
Type of exam	**Type of exam** Oral project exam in groups with individual assessment. Permitted group size: 2-7 students. The character limits of the project report are: For 2 students: 24,000-307,200 characters, including spaces. For 3 students: 24,000-307,200 characters, including spaces. For 4 students: 24,000-307,200 characters, including spaces. For 5 students: 24,000-307,200 characters, including spaces. For 6 students: 24,000-307,200 characters, including spaces. For 7 students: 24,000-307,200 characters, including spaces. The character limits include the cover, table of contents, summary, bibliography, figures and other illustrations, but exclude any appendices. The project report must include a summary in English, that is part of the assessment. Time allowed for exam including time used for assessment is for: 2 students: 60 minutes. 3 students: 75 minutes. 4 students: 90 minutes. 5 students: 105 minutes. 6 students: 120 minutes. 7 students: 135 minutes. Writing and spelling skills in the project report are part of the assessment. Permitted support and preparation materials at the oral exam: All Assessment: 7-point grading scale. Moderation: Internal co-assessor. Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Project-Oriented Internship**

Type of activity	Project oriented internship
Mandatory or elective	Elective
ECTS-rating	15 ECTS
Teaching language	English
Overall objective	The purpose of the project-oriented internship is that the student engages and works in a professional environment, where analysis of specific complex biological data and/or mathematical models of biological systems play a role. The student will achieve experience with using the thinking and methodology learned in the programme, but in a practical and different context. The student will write a project report based on the internship; this can either report the results of the work done during the internship in a scientific manner or report the work along with an analysis and reflection of the role mathematical bioscience plays in the specific organization where the internship is carried out.
Overall learning outcomes	After completing the project-oriented internship the student will be able to • present and reflect on the experience of working in an institution/company engaged in teaching, research, development or application of mathematical modelling of biological systems • argue which experimental/theoretical/analytical methods that are relevant to the selected research question including the strengths and weaknesses of the methods applied • plan and perform practical tasks by applying the methods and fundamental theories used in mathematical modelling according to the opportunities offered in a specific organisation. • analyze and present results achieved on the basis of the relevant theories and methods. • reflect critically on the practices of a specific organization • participate actively and autonomously in solving assignments in organizations where mathematical modelling and understanding of biological systems and processes contribute to create value to the organization • enter a dialogue with other professional groups on how their own knowledge and skills can contribute to a qualified execution of tasks • discuss the significance of the results achieved critically based on the relevant methods and theories and to relate the results to selected scientific literature in the area.
Type of exam	**Type of exam** Oral exam based on project oriented internship.

	The character limit of the written product is: 24,000-307,200 characters, including spaces. The character limits include the cover, table of contents, bibliography, figures and other illustrations, but exclude any appendices. Time allowed for exam including time used for assessment: 30 minutes. The assessment is an assessment of the written product and the oral performance. Spelling and communication skills in the report are part of the assessment. Permitted support and preparation materials for the oral exam: All. Assessment: 7-point grading scale. Moderation: Internal co-assessor. Each semester the Board of Studies will choose the exam type if more than one is listed.

Title	**Master Thesis**
Type of activity	Master Thesis
Mandatory or elective	Mandatory
ECTS-rating	30 ECTS
Teaching language	English
Overall objective	The overall purpose of the master thesis is that the student explores a current/exemplary and concrete research challenge that originates from biology. The exploration must include mathematical formalism and reasoning, for example, through development of a model.
Overall learning outcomes	After the master thesis the student will be able to • independently analyse, categorise, discuss, argue, reflect and solve biological research challenges based mathematical formalism and reasoning • independently and critically select mathematical and biological and general natural science sources, including literature, theory, models, and methods in order to solve biological research challenges • communicate research questions, formulate biological hypotheses, results, and conclusions to both biologists and

	mathematicians in a multi-disciplinary and critically reflected manner • independently organise workflow, plan, test, and conclude on a problem-oriented research question
Type of exam	**Type of exam** Master thesis written individually or in a group. Permitted group size: 2-4 students. The student(s) can choose whether the assessment should be based on solely the written product or on both the written product and the oral exam. The character limits of the master thesis are: for 1 student: 24,000-367,200 characters, including spaces. For 2 students: 24,000-367,200 characters, including spaces. For 3 students: 24,000-367,200 characters, including spaces. For 4 students: 24,000-367,200 characters, including spaces. The character limits include the cover, table of contents, summary, bibliography, figures and other illustrations, but exclude any appendices. The master thesis must include a summary. The summary can either be written in English or Danish. The summary is included in the overall assessment. Before submitting a master thesis written by a group, that have chosen an assessment solely based on the written product, each member of the group must clearly indicate which part(s) of the thesis they are responsible for. All group members are responsible for the introduction, conclusion and summary. The oral exam is individual for students that have written the thesis alone, or students that have requested an individual exam. All other oral master thesis exams are conducted as group exams. Time allowed for exam including time used for assessment for: 1 student: 30 minutes. 2 students: 60 minutes. 3 students: 75 minutes. 4 students: 90 minutes. There will be an individual assessment of each student's performance. The assessment is an overall assessment of the master thesis and, where relevant, the oral performance. Writing and spelling skills in the thesis are part of the assessment.

	Permitted support and preparation materials at the oral exam: All. Assessment: 7-point grading scale. Moderation: External examiner. Each semester the Board of Studies will choose the exam type if more than one is listed.

8. Approval

8.1 Approved by the Board of Studies

Studienævn for Naturvidenskabelige uddannelser on 25 June 2021.

The chairperson for external examiners and the panel of employer representatives are informed about major amendments before the study regulation comes into force.

8.2 Approved by the Dean and the Vice-Dean

Approved by the Dean and the Vice-Dean ofDepartment of Science and Environment on 14 October 2021.

8.3 Approved by the Rector

Approved by Rector Hanne Leth Andersen on 27 October 2021.