Programme-specific Section of the Curriculum for the MSc Programme in Bioinformatics at the Faculty of Science, University of Copenhagen
2017 (rev. 2022)

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1 Title, affiliation and language
A shared section that applies to all BSc and MSc Programmes at the Faculty of Science is linked to this programme-specific curriculum.

1.1 Title
The MSc Programme in Bioinformatics leads to a Master of Science (MSc) in Bioinformatics with the Danish title: Cand.scient. (candidatus/candidata scientiarum) i bioinformatik.

1.2 Affiliation
The programme is affiliated with the Study Board for the Biological Area and the students can both elect, and be elected, to this study board.

1.3 Corps of external examiners
The following corps of external examiners is used for the central parts of the MSc Programme:
- Corps of External Examiners for Computer Science (datalogi) with possibility of bringing in examiners from Corps of External Examiners for Biology (biologi).

1.4 Language
The language of this MSc Programme is English.

2 Academic profile
2.1 Purpose
The MSc Programme in Bioinformatics aims to qualify students to work on an interdisciplinary scientific basis with bioinformatics in both the public and private sectors. The specialisations Computational Biology and Computer Science will focus on biological data analysis and method and algorithm development, respectively.

2.2 General programme profile
The first year the student follows both compulsory courses in bioinformatics and courses that complement their competences from their BSc. Hereby, all students will have competences in both molecular biology (biochemistry and biology) and computer science (mathematics and statistics). In addition, the student follows supplementary courses that prepare them for a specialisation during their thesis thereby creating an individual academic profile.

Bioinformatics is the key subject area of the programme. Bioinformatics uses mathematical, statistical and computational techniques in DNA sequence analysis, protein and RNA structural analysis, genomics and analysis of high-output data to solve biological problems.

2.3 General structure of the programme
The MSc Programme is set at 120 ECTS.

The MSc Programme in Bioinformatics consists of the following elements:
- Specialisation, 120 ECTS, including the thesis.
The student must choose one of the following specialisations:
- Computational Biology
- Computer Science
2.4 Career opportunities
The MSc Programme in Bioinformatics qualifies students to become professionals within business functions and/or areas such as:

- A PhD programme
- Pharmaceutical and biotech companies.
- Hospitals.
- Research institutions, public and private, and in universities.

3 Description of competence profiles
Students following the MSc Programme acquire the knowledge, skills and competences listed below. Students will also acquire other qualifications through elective courses and other study activities.

3.1 Computational Biology
Graduates holding an MSc in Bioinformatics with a specialisation in Computational Biology have acquired the following:

Knowledge about:
- The fields of biological sequence analysis, molecular phylogeny, structural bioinformatics, systems biology and the bioinformatics aspects of gene expression and proteomics data.
- A wide range of computer programs used in bioinformatics.
- Relevant aspects of genetics, molecular biology, cell biology, mathematics, statistics, computer science and machine learning.
- Bioinformatics scientific literature and latest research and knowledge within the subject area.
- The industrial and medical applications of the subject's results.
- The use of computer science methods in molecular biology and how the two fields are integrated

Skills in/to:
- Process, interpret and evaluate large biological datasets.
- Identify and extract information about complex biological processes from data and identify computational and statistical issues associated with the analysis of such data.
- Use information technology, including databases, scripting languages and programs, in an efficient and appropriate manner, and develop small programs.
- Apply techniques described in the bioinformatics scientific literature and assess their applicability to a given biological problem
- Understand biological and biomedical experiments and research questions and suggest appropriate bioinformatics and experimental analyzes.
- Communicate knowledge and build bridges in interdisciplinary groups.
- Independently formulate new biological questions, and design computational protocols to systematically address them.

Competences in/to:
- Manage work and development situations that are complex, unpredictable and require new model solutions.
- Independently initiate and implement academic and interdisciplinary partnerships, and assume professional responsibility.
- Taking independent responsibility for their own academic development and specialisation.
• Develop computer programs or scripts for bioinformatics analyses.
• Acquire new computational skills needed for a specific bioinformatics problem.
• Read and understand scientific articles concerning computational methods and machine learning methods.
• Take independent responsibility for their own academic development and specialisation

3.2 Computer Science
Graduates holding an MSc in Bioinformatics with a specialisation in Computer Science have acquired the following:

Knowledge about:
• The fields of biological sequence analysis, molecular phylogeny, structural bioinformatics, systems biology and the bioinformatics aspects of gene expression and proteomics data.
• A broad range of standard algorithms used in Bioinformatics, in particular in the analysis of biological sequences.
• Relevant aspects of genetics, molecular biology, cell biology, mathematics, statistics, computer science and machine learning.
• Scientific literature and latest research and knowledge within the subject area of Bioinformatics.
• The algorithmic basis for a wide range of popular bioinformatics methods.
• Relevant techniques in machine learning, algorithms, statistical modelling and large scale data analysis.
• The use of machine learning, algorithms and probabilistic models in bioinformatics.
• Algorithms relevant to bioinformatics.
• Machine learning relevant to bioinformatics.
• How molecular biology and computer science are integrated in modern scientific practice.

Skills in/to:
• Process, interpret and evaluate large biological datasets.
• Identify and extract information about complex biological processes from data and identify computational and statistical issues associated with the analysis of such data.
• Use information technology, including databases and programs, in an efficient and appropriate manner, and develop small programs.
• Apply techniques described in the bioinformatics scientific literature and assess their applicability to a given biological problem.
• Independently analyze, implement and improve on bioinformatics methods.
• Scaling of existing methods and software for large amount of data.
• Apply and implement modern machine learning methods to bioinformatics problems.
• Design and implement algorithms and machine learning solutions to problems in bioinformatics.
• Read and understand scientific articles in the field of bioinformatics and molecular biology.

Competences in/to:
• Manage work and development situations that are complex, unpredictable and require new model solutions.
• Independently initiate and implement academic and interdisciplinary partnerships, and assume professional responsibility.
• Take independent responsibility for his/her own academic development and specialisation.
• Develop computer programs or scripts for bioinformatics analyses.
• Communicate and collaborate with biologists and biochemists.
• Search and gain new knowledge on the relevant biology needed to solve a problem in bioinformatics.
• Design new bioinformatical methods, using modern machine learning methods and algorithms were needed, to address biological problems.
• Evaluate the computational complexity of various solutions a problem in bioinformatics.
• Take independent responsibility for their own academic development and specialisation

4 Admission requirements
There is no BSc Programme with reserved access for this programme.

4.1 Applicants with a closely related Bachelor’s degree
Applicants with a Bachelor’s degree in the following are directly academically qualified for admission to the MSc programme in Bioinformatics:

• Applicants with a Bachelor’s degree in Biology, Biology-Biotechnology, Biochemistry, Computer Science, Machine Learning and Data Science, Mathematics, Molecular Biomedicine, Natural Sciences and IT or Physics from the University of Copenhagen.

4.2 Applicants with a Bachelor’s degree within the field of natural science or technical science
Applicants with a Bachelor’s degree within the field of natural science or technical science from the University of Copenhagen or other Danish or international universities may also be admitted if the programme includes the following:

• Courses in molecular biology, genetics and biochemistry corresponding to a minimum of 30 ECTS.
  or
• Courses in statistics, computer science, mathematics and physics corresponding to a minimum of 30 ECTS.

4.3 Other applicants
The Faculty may also admit applicants who, after an individual academic assessment, are assessed to possess educational qualifications equivalent to those required in Subclauses 4.1-3.

4.4 Language requirements
Applicants must as a minimum document English language qualifications comparable to a Danish upper secondary school English B level or English proficiency corresponding to the tests and scores required. Accepted tests and required minimum scores are published online at www.science.ku.dk.

4.5 Supplementary subject elements
The qualifications of an applicant to the MSc programme are assessed exclusively on the basis of the qualifying bachelor’s degree. Supplementary subject elements passed between the completion of the bachelor’s programme and the admission to the MSc programme cannot be included in the overall assessment.
However, subject elements passed before the completion of the bachelor’s programme may be included in the overall assessment. This includes subject elements completed as continuing education as well as subject elements completed as part of a former higher education programme. A maximum of 30 ECTS supplementary subject elements can be included in the overall assessment.

Subject elements passed before completing the BSc programme which are to form part of the MSc programme to which the student has a legal right of admission (§12-courses) cannot be included in the overall assessment.

5 Prioritisation of applicants
If the number of qualified applicants to the programme exceeds the number of places available, applicants will be prioritised as follows:

1) Applicants with a Bachelor’s degree in Machine Learning and Data Science from the University of Copenhagen.
2) Applicants with a Bachelor’s degree within the field of natural science or technical science based on grades and courses taken (biology, molecular biology, biochemistry, mathematics, physics and computer science) relevant to bioinformatics. If different grading systems make comparison impossible, applicants will be prioritised on the basis of an individual evaluation by the Admission Committee.
3) Applicants with a Bachelor’s degree within the field of natural science or technical science based on the interdisciplinary nature of their education, i.e. priority will be given to applicants whose Bachelor’s degree include courses in biology, molecular biology, biochemistry, mathematics, physics and computer science.
4) Other applicants.

If the number of qualified applicants within a category exceeds the number of places available, applicants will be prioritised according to the following criteria (listed below in prioritised order):

- Number of ECTS taken in courses relevant for bioinformatics.
- Applicants with a Bachelor’s degree age of more than 5 years have low priority.

6 Structure of the programme
The compulsory subject elements, restricted elective subjects elements and the thesis constitute the central parts of the programme (Section 30 of the Ministerial Order on Bachelor and Master’s Programmes (Candidatus) at Universities).

Before the beginning of the MSc Programme the student must choose a specialisation.

6.1 Computational Biology
The specialisation is set at 120 ECTS and consists of the following:

- Compulsory subject elements, 52.5 ECTS
- Restricted elective subject elements, 22.5 ECTS
- Elective subject elements, 15 ECTS
- Thesis, 30 ECTS
### 6.1.1 Compulsory subject elements

All of the following subject elements are to be covered (52.5 ECTS)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBIA05008U</td>
<td>Biological Sequence Analysis</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIB20000U</td>
<td>Python Programming for Data Science</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIA05014U</td>
<td>Structural Bioinformatics</td>
<td>Block 2</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NMAK14029U</td>
<td>Statistics for Bioinformatics and eScience</td>
<td>Block 2</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK16003U</td>
<td>Introduction to Data Science</td>
<td>Block 3</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIA09043U</td>
<td>Population Genetics</td>
<td>Block 3</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIA07023U</td>
<td>Bioinformatics of High Throughput Analyses</td>
<td>Block 4</td>
<td>7.5 ECTS</td>
</tr>
</tbody>
</table>

### 6.1.2 Restricted elective subject elements

22.5 ECTS are to be covered as subject elements from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBIK10017U</td>
<td>RNA Biology</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK14008U</td>
<td>Programming Massively Parallel Hardware</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK15014U</td>
<td>Advanced Topics in Machine Learning</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK10005U</td>
<td>Medical Image Analysis</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIK20004U</td>
<td>Advanced Bioinformatics for Next-Generation Sequencing</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK22000U</td>
<td>Machine Learning A</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK21006U</td>
<td>Data Parallel Programming</td>
<td>Block 2</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAA09023U</td>
<td>Advanced Algorithms and Data Structures</td>
<td>Block 2</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIK14031U</td>
<td>Molecular Biology for Non-life Scientists</td>
<td>Block 2</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK10009U</td>
<td>Computational Geometry</td>
<td>Block 3</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAA09009U</td>
<td>Numerical Optimization</td>
<td>Block 3</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK14007U</td>
<td>Applied Programming</td>
<td>Block 4</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK14005U</td>
<td>Randomized Algorithms</td>
<td>Block 4</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIK21000U</td>
<td>Phylogenomic Applications in Biodiversity Research</td>
<td>Block 5</td>
<td>5 ECTS</td>
</tr>
<tr>
<td>NBIK10005U</td>
<td>Bioinformatics Project 1</td>
<td>Block 1-5</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIK10008U</td>
<td>Bioinformatics Project 2</td>
<td>Block 1-5</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIK10009U</td>
<td>Bioinformatics Project 3</td>
<td>Block 1-5</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIK10010U</td>
<td>Bioinformatics Project 4</td>
<td>Block 1-5</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIK10013U</td>
<td>Individual Project in Bioinformatics</td>
<td>Block 1-5</td>
<td>15 ECTS</td>
</tr>
</tbody>
</table>

### 6.1.3 Elective subject elements

15 ECTS are to be covered as elective subject elements.

- All subject elements at MSc level may be included as elective subject elements in the MSc Programme.
- BSc subject elements corresponding to 15 ECTS may be included in the MSc Programme.
- Projects. See 6.1.4 Projects.

### 6.1.4 Projects

Projects outside the course scope, projects in practice and thesis preparation projects may not exceed 30 ECTS of the programme.

- Projects outside the course scope may be included in the elective section of the programme with up to 15 ECTS. The regulations are described in Appendix 5 to the shared section of the curriculum.
• Projects in practice may be included in the elective section of the programme with up to 15 ECTS. The regulations are described in Appendix 4 to the shared section of the curriculum.
• Thesis preparation projects may be included in the elective section of the programme with up to 7.5 ECTS. The regulations are described in Appendix 6 to the shared section of the curriculum.

6.1.5 Thesis
The MSc Programme in Bioinformatics with a specialisation in Computational Biology includes a thesis corresponding to 30 ECTS, as described in Appendix 2 to the shared curriculum. The thesis must be written within the academic scope of the MSc programme.

6.1.6 Academic mobility
The curriculum makes it possible to follow subject elements outside the Faculty of Science.

The academic mobility for the MSc Programme in Bioinformatics with a specialisation in Computational Biology is placed in block 1+2 of the 2nd year.

Academic mobility requires that the student follows the rules and regulations regarding pre-approval and credit transfer.

In addition, the student has the possibility to arrange similar academic mobility in other parts of the programme.

6.2 Computer Science
The specialisation is set at 120 ECTS and consists of the following:
• Compulsory subject elements, 37.5 ECTS
• Restricted elective subject elements, 37.5 ECTS
• Elective subject elements, 15 ECTS
• Thesis, 30 ECTS

6.2.1 Compulsory subject elements
All of the following subject elements are to be covered (37.5 ECTS):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBIA05008U</td>
<td>Biological Sequence Analysis</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
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<tr>
<td>NDAK22000U</td>
<td>Machine Learning A</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIK14031U</td>
<td>Molecular Biology for Non-life Scientists</td>
<td>Block 2</td>
<td>7.5 ECTS</td>
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<tr>
<td>NBIA05014U</td>
<td>Structural Bioinformatics</td>
<td>Block 2</td>
<td>7.5 ECTS</td>
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<td>NDAA09023U</td>
<td>Advanced Algorithms and Data Structures</td>
<td>Block 2</td>
<td>7.5 ECTS</td>
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6.2.2 Restricted elective subject elements
37.5 ECTS are to be covered as subject elements from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBIK10017U</td>
<td>RNA Biology</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK14008U</td>
<td>Programming Massively Parallel Hardware</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK15014U</td>
<td>Advanced Topics in Machine Learning</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK10005U</td>
<td>Medical Image Analysis</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK14003U</td>
<td>Discrete Optimization</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
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<tr>
<td>NBIK20004U</td>
<td>Advanced Bioinformatics for Next-Generation Sequencing</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
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<td>NMAK14029U</td>
<td>Statistics for Bioinformatics and eScience (StatBIE)</td>
<td>Block 2</td>
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<tr>
<td>Course Code</td>
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<td>Block</td>
<td>ECTS</td>
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<tr>
<td>NDAK21006U</td>
<td>Data Parallel Programming</td>
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<td>NDAK10009U</td>
<td>Computational Geometry</td>
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<td>NDAAD09009U</td>
<td>Numerical Optimisation</td>
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<td>Population Genetics</td>
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<td>Applied Programming</td>
<td>Block 4</td>
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<td>Bioinformatics of High Throughput Analyses</td>
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<td>7.5 ECTS</td>
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<tr>
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<td>Phylogenomic Applications in Biodiversity Research</td>
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<td>5 ECTS</td>
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<td>NBIK10013U</td>
<td>Individual Project in Bioinformatics</td>
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<td>NBIK10008U</td>
<td>Bioinformatics Project 2</td>
<td>Block 1-5</td>
<td>7.5 ECTS</td>
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<td>NBIK10009U</td>
<td>Bioinformatics Project 3</td>
<td>Block 1-5</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NBIK10010U</td>
<td>Bioinformatics Project 4</td>
<td>Block 1-5</td>
<td>7.5 ECTS</td>
</tr>
</tbody>
</table>

**6.2.3 Elective subject elements**
15 ECTS are to be covered as elective subject elements.
- All subject elements at MSc level may be included as elective subject elements in the MSc Programme.
- BSc subject elements corresponding to 15 ECTS may be included in the MSc Programme.
- Projects. See 6.2.4 Projects.

**6.2.4 Projects**
Projects outside the course scope, projects in practice and thesis preparation projects may not exceed 45 ECTS of the programme.
- Projects outside the course scope may be included in the elective section of the programme with up to 15 ECTS. The regulations are described in Appendix 5 to the shared section of the curriculum.
- Projects in practice may be included in the elective section of the programme with up to 15 ECTS. The regulations are described in Appendix 4 to the shared section of the curriculum.
- Thesis preparation projects may be included in the elective section of the programme with up to 7.5 ECTS. The regulations are described in Appendix 6 to the shared section of the curriculum.

**6.2.5 Thesis**
The MSc Programme in Bioinformatics with a specialisation in Computer Science includes a thesis corresponding to 30 ECTS, as described in Appendix 2 to the shared curriculum. The thesis must be written within the academic scope of the MSc programme.

**6.2.6 Academic mobility**
Academic mobility requires that the student follows the rules and regulations regarding pre-approval and credit transfer.

The academic mobility for the MSc Programme in Bioinformatics with a specialisation in Computer science is placed in block 3+4 of the 1st year. This means that the curriculum makes it possible to follow subject elements outside the Faculty of Science.

In addition, the student has the possibility to arrange similar academic mobility in other parts of the programme.
7 Exemptions
In exceptional circumstances, the study board may grant exemptions from the rules in the curriculum specified solely by the Faculty of Science.

8 Commencement etc.

8.1 Validity
This subject specific section of the curriculum applies to all students enrolled on the programme – see however Appendix 2.

8.2 Transfer
Students enrolled on previous curricula may be transferred to the new one as per the applicable transfer regulations or according to an individual credit transfer by the study board.

8.3 Amendment
The curriculum may be amended once a year so that any changes come into effect at the beginning of the academic year. Amendments must be proposed by the study board and approved by the Dean.

Notification about amendments that tighten the admission requirements for the programme will be published online at www.science.ku.dk one year before they come into effect.

If amendments are made to this curriculum, an interim arrangement may be added if necessary to allow students to complete their MSc Programme according to the amended curriculum.
Appendix 1 The recommended academic progression
The table illustrates the recommended academic progression. The student is allowed to plan an alternative progression within the applicable rules.

Table - MSc Programme in Bioinformatics with a specialisation in Computational Biology

<table>
<thead>
<tr>
<th></th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
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</thead>
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<tr>
<td>1st year</td>
<td>Python Programming for Data Science</td>
<td>Statistics for Bioinformatics and eScience</td>
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<td>Biological Sequence Analysis</td>
<td>Structural Bioinformatics</td>
<td>Introduction to Data Science</td>
<td>Bioinformatics of High Throughput Analyses</td>
</tr>
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<td>2nd year</td>
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<td>Restricted elective</td>
<td></td>
<td>Thesis</td>
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<td>Elective</td>
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Table - MSc Programme in Bioinformatics with a specialisation in Computer Science

<table>
<thead>
<tr>
<th></th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year</td>
<td>Machine Learning A</td>
<td>Molecular Biology for Non-life Scientists</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td></td>
<td>Biological Sequence Analysis</td>
<td>Structural Bioinformatics</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td>2nd year</td>
<td>Restricted elective</td>
<td>Advanced Algorithms and Data Structures</td>
<td></td>
<td>Thesis</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 2 Interim arrangements

The Shared Section of the BSc and MSc Curricula for Study Programmes applies to all students.

The interim arrangements below only consist of parts where the current curriculum differs from the rules and regulations that were previously valid. Therefore, if information about relevant rules and regulations are missing, it can be found in the curriculum above.

1 General changes for students admitted in the academic year 2021/22
Students admitted to the MSc Programme in the academic year 2021/22 must finish the programme as listed in the curriculum above with the following exceptions.

1.1 Specialisation in Computational Biology

Restricted elective subject elements

<table>
<thead>
<tr>
<th>Restricted elective subject elements offered as part of the specialisation in Computational Biology in this curriculum (see above)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDAK15007U</td>
</tr>
</tbody>
</table>

* See discontinued courses below.

1.2 Specialisation in Computer Science

Structure of the programme

The specialisation is set at 120 ECTS and consists of the following:

- Compulsory subject elements, 37.5 ECTS
- Restricted elective subject elements, 37.5 ECTS
- Elective subject elements, 15 ECTS
- Thesis, 30 ECTS

Table - MSc Programme in Bioinformatics with a specialisation in Computer Science

<table>
<thead>
<tr>
<th></th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year</td>
<td>Machine Learning*</td>
<td>Molecular Biology for Non-life Scientists*</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td></td>
<td>Biological Sequence Analysis</td>
<td>Structural Bioinformatics</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td>2nd year</td>
<td>Restricted elective</td>
<td>Advanced Algorithms and Data Structures*</td>
<td></td>
<td>Thesis</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subject elements in italics have been discontinued. See discontinued courses below.

*Machine Learning was originally placed in block 2. Molecular Biology for Non-life Scientists was originally placed in block 1. Advanced Algorithms and Data Structures was originally placed in block 1.

2 General changes for students admitted in the academic year 2020/21
Students admitted to the MSc Programme in the academic year 2020/21 must finish the programme as listed in the curriculum above with the following exceptions.
2.1 Specialisation in Computational Biology

Restricted elective subject elements

22.5 ECTS are to be covered as subject elements from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDAK14009U</td>
<td>Parallel Functional Programming</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK15007U</td>
<td>Machine Learning</td>
<td>7.5 ECTS</td>
</tr>
</tbody>
</table>

* See discontinued courses below.

2.2 Specialisation in Computer Science

Structure of the programme

The specialisation is set at 120 ECTS and consists of the following:

- Compulsory subject elements, 37.5 ECTS
- Restricted elective subject elements, 37.5 ECTS
- Elective subject elements, 15 ECTS
- Thesis, 30 ECTS

Table - MSc Programme in Bioinformatics with a specialisation in Computer Science

<table>
<thead>
<tr>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Learning*</td>
<td>Molecular Biology for Non-life Scientists*</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td>Biological Sequence Analysis</td>
<td>Structural Bioinformatics</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td>Restricted elective</td>
<td>Advanced Algorithms and Data Structures*</td>
<td>Thesis</td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subject elements in italics have been discontinued. See discontinued courses below.

*Machine Learning was originally placed in block 2. Molecular Biology for Non-life Scientists was originally placed in block 1. Advanced Algorithms and Data Structures was originally placed in block 1.

Restricted elective subject elements

37.5 ECTS are to be covered as subject elements from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDAK14009U</td>
<td>Parallel Functional Programming</td>
<td>7.5 ECTS</td>
</tr>
</tbody>
</table>

* See discontinued courses below.

3 General changes for students admitted in the academic year 2019/20 or 2018/19

Students admitted to the MSc Programme in the academic year 2019/20 or 2018/19 must finish the programme as listed in the curriculum above with the following exceptions.

3.1 Specialisation in Computational Biology

Structure of the programme

The specialisation is set at 120 ECTS and consists of the following:

- Compulsory subject elements, 52.5 ECTS
- Restricted elective subject elements, 22.5 ECTS
- Elective subject elements, 15 ECTS
- Thesis, 30 ECTS

Table - MSc Programme in Bioinformatics with a specialisation in Computational Biology

<table>
<thead>
<tr>
<th>Year</th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Linux and Python Programming</td>
<td>Statistics for Bioinformatics and eScience</td>
<td>Population Genetics</td>
<td>Restricted elective</td>
</tr>
<tr>
<td></td>
<td>Biological Sequence Analysis</td>
<td>Structural Bioinformatics</td>
<td>Introduction to Data Science</td>
<td>Bioinformatics of High Throughput Analyses</td>
</tr>
<tr>
<td>2nd</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td></td>
<td>Thesis</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subject elements in italics have been discontinued. See discontinued courses below.

Restricted elective subject elements

22.5 ECTS are to be covered as subject elements from the following list:

Restricted elective subject elements offered as part of the specialisation in Computational Biology in this curriculum (see above)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>ECTS</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBIK15022U</td>
<td>Advanced Topics in Bioinformatics</td>
<td>7.5</td>
<td>Discontinued*</td>
</tr>
<tr>
<td>NDAK14009U</td>
<td>Parallel Functional Programming</td>
<td>7.5</td>
<td>Discontinued*</td>
</tr>
<tr>
<td>NDAK15007U</td>
<td>Machine Learning</td>
<td>7.5</td>
<td>Discontinued*</td>
</tr>
</tbody>
</table>

* See discontinued courses below.

3.2 Specialisation in Computer Science

Structure of the programme

The specialisation is set at 120 ECTS and consists of the following:

- Compulsory subject elements, 37.5 ECTS
- Restricted elective subject elements, 37.5 ECTS
- Elective subject elements, 15 ECTS
- Thesis, 30 ECTS

Table - MSc Programme in Bioinformatics with a specialisation in Computer Science

<table>
<thead>
<tr>
<th>Year</th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Machine Learning*</td>
<td>Molecular Biology for Non-life Scientists*</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td></td>
<td>Biological Sequence Analysis</td>
<td>Structural Bioinformatics</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td>2nd</td>
<td>Restricted elective</td>
<td>Advanced Algorithms and Data Structures*</td>
<td></td>
<td>Thesis</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subject elements in italics have been discontinued. See discontinued courses below.
*Machine Learning was originally placed in block 2. Molecular Biology for Non-life Scientists was originally placed in block 1. Advanced Algorithms and Data Structures was originally placed in block 1.

**Restricted elective subject element**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>ECTS</th>
<th>Interim arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBIK15022U</td>
<td>Advanced Topics in Bioinformatics</td>
<td>7.5</td>
<td>The course was a restricted elective course on the specialisation in Computer Science and Computational Biology in the academic year 2019/20 and 2018/19. Offered for the last time: 2019/20 The course is identical to Advanced Bioinformatics for Next-Generation Sequencing (NBIK20004U), 7.5 ECTS</td>
</tr>
<tr>
<td>NBIK14032U</td>
<td>Linux and Python Programming</td>
<td>7.5</td>
<td>The course was compulsory on the specialisation in Computational Biology in the academic year 2019/20 and 2018/19. Offered for the last time: 2019/20 Last exam if applicable (cf. SCIENCE's Teaching and exam rules): 2020/21 In this curriculum Python Programming for Data Science (NBIB20000U), 7.5 ECTS ECTS replaces the course.</td>
</tr>
<tr>
<td>NDAK15007U</td>
<td>Machine Learning</td>
<td>7.5</td>
<td>The course was compulsory on the specialisation in Computer Science and restricted elective on the specialisation in Computational Biology in the academic year 2021/22, 2020/21, 2019/20 and 2018/19. Offered for the last time: 2021/22 Last exam if applicable (cf. SCIENCE's Teaching and exam rules): 2022/23. Machine Learning A (NDAK22000U), 7.5 ECTS replaces Machine Learning as a compulsory course.</td>
</tr>
</tbody>
</table>

4 Discontinued courses

- NBIK15022U: Advanced Topics in Bioinformatics (Discontinued*) 7.5 ECTS
- NDAK14009U: Parallel Functional Programming (Discontinued*) 7.5 ECTS

* See discontinued courses below.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDAK14009U</td>
<td>Parallel Functional Programming</td>
<td>7.5</td>
</tr>
</tbody>
</table>

The course was a restricted elective course on the specialisation in Computer Science and Computational Biology in the academic year 2020/21, 2019/20 and 2018/19.

Offered for the last time: 2020/21

The course is identical to Data Parallel Programming (NDAK21006U), 7.5 ECTS
Appendix 3 Description of objectives for the thesis

After completing the thesis, the student should have:

Knowledge about:
- Solid interdisciplinary knowledge in the fields of biological sequence analysis, molecular phylogeny, structural bioinformatics, systems biology and the bioinformatics aspects of gene expression and proteomics data.
- Knowledge at the highest international level within an area of specialisation.
- Knowledge of relevant aspects of genetics, molecular biology, cell biology, mathematics, statistics, computer science and machine learning.
- Understanding of bioinformatics scientific literature, and are able to reflect scientifically on knowledge within the subject area and identify scientific problems.
- Familiarity with the industrial and medical applications of the subject's results.

Skills in/to:
- Process, interpret and evaluate large biological datasets.
- Identify and extract information about complex biological processes as well as computer science and statistical issues.
- Use information technology, including databases and programs, in an efficient and appropriate manner, and develop small programs.
- Evaluate and apply techniques described in bioinformatics scientific literature.
- Communicate knowledge and build bridges in interdisciplinary groups.

Competences in/to:
- Manage work and development situations that are complex, unpredictable and require new model solutions.
- Independently initiate and implement academic and interdisciplinary partnerships, and assume professional responsibility.
- Taking independent responsibility for their own academic development and specialisation.