



# Programme-specific Section of the Curriculum for the MSc Programme in Bioinformatics at the Faculty of Science, University of Copenhagen 2009-2016 (Rev. 2018)

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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.

### 2.2 General programme profile

The first year the student follow 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.

There are no defined specialisations in this programme.

### 2.4 Career opportunities

The MSc Programme in Bioinformatics qualifies students for a PhD programme, and depending on the academic specialisation it may also be targeted at business functions and/or areas such as:

- 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 Competence profile

On completion of the programme, an MSc in Bioinformatics has 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 knowledge within the subject area.
- 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.
- Develop computer programs or scripts for bioinformatics analyses.

### 4 Admission requirements

With a Bachelor's degree in Natural Science and IT from the University of Copenhagen the student is granted reserved access and guaranteed a place on the MSc Programme in Bioinformatics if the student applies before the application deadline during the first application period after the completion of the Bachelor's degree.

#### 4.1 Applicants with a Bachelor's degree in Natural Sciences and IT

Applicants with a Bachelor's degree in Natural Sciences and IT from the University of Copenhagen are directly academically qualified for admission to the MSc programme.

#### 4.2 Applicants with a related Bachelor's degree

Applicants with a Bachelor's degree in Biology, Biology-Biotechnology, Biochemistry, Molecular Biomedicine, Computer Science, Physics and Mathematics from the University of Copenhagen are directly academically qualified for admission to the MSc Programme.

### **4.3 Applicants with a Bachelor's degree within the field of science or technical science**

Applicants with a Bachelor's degree within the field of 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 deemed to possess educational qualifications equivalent to those required in Subclauses 4.1-3.

### **4.4 Language requirements**

#### ***4.4.1 Applicants from Nordic universities***

Applicants with a Bachelor's degree from Nordic universities must as a minimum document English language qualifications comparable to a Danish upper secondary school English B level.

#### ***4.4.2 Non-Nordic applicants***

Applicants with a non-Nordic Bachelor's degree must be able to document English proficiency corresponding to an IELTS test score of minimum 6.5 or a TOEFL test score of minimum 83 (Internet-based).

## **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 Natural Sciences and IT from the University of Copenhagen seeking admission by way of direct extension of their completed BSc programme.
- 2) Applicants based on grades and courses taken (biology, molecular biology, biochemistry, mathematics, physics and computer science) relevant to bioinformatics.
- 3) Applicants with a Bachelor's degree within the field of 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.

Applicants are then prioritised according to the relevance of courses taken and previous experience within bioinformatics.

## **6 Structure of the programme**

The compulsory subject elements, restricted elective subjects elements and the thesis constitute the central parts of the programme (Section 21 of the Ministerial Order on Bachelor and Master's Programmes (Candidatus) at Universities).

### **6.1 Programme components**

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

- Compulsory subject elements, 30 ECTS

- Restricted elective subject elements, 45 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 (30 ECTS):

• NBIA05008U	Biological Sequence Analysis	Block 1	7.5 ECTS
• NBIA05014U	Structural Bioinformatics	Block 2	7.5 ECTS
• NBIA09043U	Population Genetics	Block 3	7.5 ECTS
• NBIA07023U	Bioinformatics of High Throughput Analysis	Block 4	7.5 ECTS

### 6.1.2 Restricted elective subject elements

45 ECTS are to be covered as subject elements from the following two lists:

1) 7.5 ECTS are to be covered as subject elements from the following list:

• NBIK14031U	Molecular Biology for Non-life Sciences*	Block 1	7.5 ECTS
• NBIK14032U	Linux and Python Programming*	Block 1	7.5 ECTS

\*One of the two courses must be followed in block 1, year 1.

2) 37.5 ECTS are to be covered as subject elements from the following list:

• NBIK10017U	RNA Biology	Block 1	7.5 ECTS
• NDAK14008U	Programming Massively Parallel Hardware	Block 1	7.5 ECTS
• NBIK15022U	Advanced Topics in Bioinformatics	Block 1	7.5 ECTS
• NDAK15014U	Advanced Topics in Machine Learning	Block 1	7.5 ECTS
• NDAK10005U	Medical Image Analysis	Block 1	7.5 ECTS
• NDAA09023U	Advanced Algorithms & Data Structures	Block 1	7.5 ECTS
• NBIK15017U	Theoretical Molecular Genetics	Block 1	7.5 ECTS
• NDAK14003U	Discrete Optimization	Block 1	7.5 ECTS
• NDAK14009U	Parallel Functional Programming	Block 2	7.5 ECTS
• NDAK15017U	Interactive Data Exploration	Discontinued*	7.5 ECTS
• NMAK14029U	Statistics for Bioinformatics and eScience (StatBI/E)	Block 2	7.5 ECTS
• NDAK15007U	Machine Learning (ML)	Block 2	7.5 ECTS
• NDAK16003U	Introduction to Data Science	Block 3	7.5 ECTS
• NDAK10009U	Computational Geometry	Block 3	7.5 ECTS
• NDAA09009U	Numerical Optimization	Block 3	7.5 ECTS
• NBIA08011U	Statistics for Molecular Biomedicine	Block 3	7.5 ECTS
• NDAK14007U	Applied Programming (APP)	Block 4	7.5 ECTS
• NDAK14005U	Randomized Algorithms	Block 4	7.5 ECTS
• NBIK10005U	Bioinformatics Project 1	Block 1-5	7.5 ECTS
• NBIK10008U	Bioinformatics Project 2	Block 1-5	7.5 ECTS
• NBIK10009U	Bioinformatics Project 3	Block 1-5	7.5 ECTS
• NBIK10010U	Bioinformatics Project 4	Block 1-5	7.5 ECTS
• NBIK10013U	Individual Project in Bioinformatics	Block 1-5	15 ECTS

\*See course specific changes below.

#### **6.1.4 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 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.

#### **6.1.5 Thesis**

The MSc Programme in Bioinformatics includes a thesis corresponding to 30 ECTS, as described in Appendix 2 to the shared curriculum. The thesis must be written full time and the topic of the thesis must be within the academic scope of the MSc programme.

#### **6.1.6 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 is placed in block 1+2 of the 2<sup>nd</sup> 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](http://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 Tables

**Table - MSc Programme in Bioinformatics**

	Block 1	Block 2	Block 3	Block 4
1st year	Biological Sequence Analysis	Structural Bioinformatics	Population Genetics	Bioinformatics of High Throughput Analysis
	Molecular Biology for Non-Life Sciences <i>Or</i> Linux and Python Programming	Restricted elective	Restricted elective	Restricted elective
2nd year	Elective	Elective	Thesis	
	Restricted elective	Restricted elective		



Compulsory



Restricted elective



Elective

The table illustrates the recommended academic progression. The student is allowed to plan an alternative progression within the applicable rules.



## 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 2015/16 or earlier

Students admitted to the MSc Programme in the academic year 2015/16 must finish the programme with the original curriculum structure under which they were admitted.

#### Restricted elective subject elements

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

• Restricted elective subject elements offered as part of the curriculum (see above)			
• NBIK14006U	Principles in Genomic Studies	Discontinued*	7.5 ECTS
• NBIK10012U	Individual Project in Bioinformatics	Discontinued*	7.5 ECTS
• NDAK15015U	Data Analysis Methods (DAM)	Discontinued*	7.5 ECTS
• NDAK15017U	Interactive Data Exploration	Discontinued*	7.5 ECTS

\*See course specific changes below.

### 2 General changes for students admitted in the academic year 2014/15 or earlier

Students admitted to the MSc Programme in the academic year 2014/15 or earlier must finish the programme with the original curriculum structure under which they were admitted.

#### Structure of the programme

For students admitted to the MSc Programme in the academic year 2014/15 or earlier the programme consists of the following:

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

**Table - MSc Programme in Bioinformatics - admitted 2014/15 or earlier**

	Block 1	Block 2	Block 3	Block 4
1 <sup>st</sup> year	Biological Sequence Analysis	Structural Bioinformatics	Population Genetics	Bioinformatics of High Throughput Analysis
	Restricted elective	Restricted elective	Restricted elective	Restricted elective
2 <sup>nd</sup> year	Elective	Elective	Thesis	
	Elective	Elective		

Compulsory
  Restricted elective
  Elective

#### Restricted elective subject elements

The former division between special courses and ancillary courses and the maximum of ancillary courses is no longer valid.

Therefore, 30 ECTS credits are to be covered by subject elements from the following lists:

<ul style="list-style-type: none"> <li>• Restricted elective subject elements offered as part of the curriculum (see above)</li> </ul>			
• NBIK14006U	Principles in Genomic Studies	Discontinued*	7.5 ECTS
• NBIK10012U	Individual Project in Bioinformatics	Discontinued*	7.5 ECTS
• NDAK15015U	Data Analysis Methods (DAM)	Discontinued*	7.5 ECTS
• NBIA04011U	Theoretical Molecular Genetics	Discontinued*	7.5 ECTS
• NDAA09028U	Statistical Methods for Machine Learning	Discontinued*	7.5 ECTS

\* See course specific changes below.

#### 4 Course specific changes

Discontinued course	Interim arrangement
Data Analysis Methods (DAM) (NDAK15015U), 7.5 ECTS	<p>The course was a restricted elective course in the academic year 2015/16 or earlier.</p> <p>The course was offered for the last time in the academic year 2015/16 and a third exam is offered in the academic year 2016/17.</p> <p>The course has changed title and is identical to Introduction to Data Science (NDAK16003U), 7.5 ECTS.</p>
Individual Project in Bioinformatics (NBIK10012U), 7.5 ECTS	<p>The course was a restricted elective course in the academic year 2015/16 or earlier.</p> <p>The course was offered for the last time in the academic year 2015/16 and a third exam is offered in the academic year 2016/17.</p>
Principles in Genomic Studies (NBIK14006U), 7.5 ECTS	<p>The course was a restricted elective course in the academic year 2015/16 or earlier.</p> <p>The course was offered for the last time in the academic year 2015/16 and a third exam is offered in the academic year 2016/17.</p>
Statistical Methods for Machine Learning (NDAA09028U), 7.5 ECTS	<p>The course was a restricted elective course in the academic year 2014/15 or earlier.</p> <p>The course was offered for the last time in the academic year 2014/15 and a third exam is offered in the academic year 2015/16.</p> <p>The course has changed title and is equivalent to Machine Learning (NDAK15007U), 7.5 ECTS.</p>
Theoretical Molecular Genetics (MolGenTeo) (NBIA04011U), 7.5 ECTS	<p>The course was a restricted elective course in the academic year 2014/15 or earlier.</p> <p>The course was offered for the last time in the academic year 2014/15 and a third exam is offered in the academic year 2015/16.</p> <p>The course has changed from bachelor's level to master's level and is equivalent to Theoretical Molecular Genetics (NBIK15017U), 7.5 ECTS.</p>

## Appendix 3 Description of objectives for the thesis

After completing the thesis, the student should have:

### Knowledge about:

- Theory and methods within bioinformatics and the selected specialisation.
- Suitable combinations of methodologies/theories in bioinformatics based on international research and the strength and limitations of the methods.
- Formulation and analysis of problems in bioinformatics.
- A wide range of computer programs used in bioinformatics.

### Skills in/to:

- Select, apply and critically evaluate theories and methods in bioinformatics, including their applicability and limitations.
- Discuss and communicate issues arising from the thesis in a scientific context.
- Draw conclusions in a clear and academic manner in relation to the problem formulation and relating it to a broader scientific context.
- Select and use a wide range of different methods and in silico analyses relevant to their specialization.
- Use standard and specialised software.

### Competences in/to:

- Initiate and perform a research oriented project independently.
- Analyse and interpret own results and conclusions based on bioinformatics principles and relate it to other peoples data.
- Put their own results in scientifically relevant context.
- Independently develop their knowledge and skills related to bioinformatics and to related areas like computer science and molecular biology.
- Solve complex problems and assess the quality, relevance and probability of their own and others results.
- Develop computer programs or scripts for bioinformatics analyses.