Department of Computer Science
Faculty of Science
Eberhard Karls University Tübingen

Module handbook

of the

M.Sc. Bioinformatics

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EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

MATHEMATISCH-
NATURWISSENSCHAFTLICHE
FAKULTÄT

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Introduction

Structure and content

This handbook describes the modules that make up the Master's programs **Computer Science**, **Bioinformatics**, **Media Informatics** and **Medical Informatics** at the Department of Computer Science (Faculty of Science, Eberhard Karls University Tübingen). The module handbook describes each of these four degree programs in separate chapters.

These Master's programs comprise **elective compulsary modules** and **study areas**, the latter encompasses cognant modules. For both elective compulsary modules and study areas a short description and the required number of credit points (see below) is given. The required number of credit points within a study area can be obtained by ompleting one or several of its modules. Which modules belong to which study area can be seen in the appendix of this module handbook, the **list of modules**.

Each study area has a prefix identifying the degree program, followed by an abbreviation identifying the study area. Each module has a prefix, followed by a code number:

Prefix	**Study area**
INFO-	Computer Science
BIO-	Bioinformatics
MEDI-	Media Informatics
MEDZ-	Medical Informatics

Examples for study areas: **INFO-PRAK** (Practical Informatics), **BIO-LIFE** (Life Sciences), **MEDI-VIS** (Computer Graphics and Visual Computing) and **MEDZ-BIOMED** (Biomedical Informatics).

Credits

All study areas and modules have *credit values*, so-called *credit points* or *ECTS* (*European Credit Transfer System*). Credit points indicate the amount of workload required to complete a module/study area. According to national and international standards (in Germany: Resolution of the Standing Conference of the Minsters of Education and Cultural Affairs, 24 October 1997), one credit point is equivalent to a (*workload*) of 30 hours of study (including both class seat time and self-study hours). Since the entire workload of one semester (including semester breaks) should not exceed 900 hours of study, students will have to earn an average of 30 credit points per semester. Credit points represent the class seat time, the number of self-study hours (preparing and reviewing classes attended), the number of hours invested in preparing for exams and writing the master thesis, as well as practical courses. Credit points are earned by attending and participating in the courses that make up the module, and by completing any course-related tasks.

Teaching methods

Seminars (if not described otherwise) are a series of sessions in which students are assigned a complex task. In addition, they have to summarize and assess concepts and methods of computer science based on systematic research, and present their results in written form and in an oral presentation in the seminar. Usually, students are also to submit a written elaboration of the task assigned to them. Assessment of a student's performance is based on the oral presentation of their results, on their participation in the discussion following the oral presentation, and on the written elaboration of the presentation.

Lectures (if not described otherwise) are a series of face-to-face talks by a lecturer, often accompanied by tutorials in which the content of the individual lecture is reviewed and discussed, and in which students are given assignments. In addition, there are face-to-face programming tutorials in which tasks related to the lecture are completed under direct supervision. Assessment of a student's performance is usually based on the result of either a written or oral exam at the end of the lecture series.

Practical courses (if not described otherwise) are sessions which involve practical work; students will complete tasks in small teams on their own or under guidance of a lecturer. Assessment of a student's performance is based on the participation, an oral presentation of the results and a written elaboration.

Research projects (if not described otherwise) offer students the opportunity to participate in the current research work of a group at the Department of Computer Science during the semester. Such projects aim e.g. at linking the Master's program to current research and preparing students for writing their Master's thesis. Assessment of a student's performance is based e.g. on a student's participation in a scientific publication or on a student's written project report and an oral presentation.

Grading

As a rule, modules are graded; grades are based on *one* type of assessed coursework (in case of lectures e.g. a written test). In exceptional cases, a grade may be based on several assessments; for details see the description of the modules. Grades are awarded by the lecturer.

In accordance with the Study and Exam Regulations, module grades with their credit points make up part of the final (Master's degree) grade.

Appendix for the module handbook

The study commission generates an appendix, the **module catalogue**, for the module handbook. This appendix lists the courses offered in the department (including a summary of the course content, objectives, and requirements for credit points / grades), and indicates to which module and study area they belong.

Legend

Category	Abbreviation and meansing
Teching method	L = Lecture S = Seminar T = Tutorial P = Practical course R = Research project
Status	c = compulsary o = optional
CH	Credit hours
CP	Credit points (= ECTS)
Type of exam	wt = written test ot = oral test tp = term paper op = oral presentation
Duration of exam	in minutes
Evaluation	g = graded ug = ungraded (pass/fail) nt = no test
Calculation of modules	possible percentage weighting of grades

Master's program Bioinformatics

General information

Program content

Students holding a Master's degree in bioinformatics will be able to analyze problems both in the area of life sciences and computer science, develop solutions, and implement and use these solutions. The bioinformatics course is based on a conceptual and methodological approach, while also being career-, research- and job market-oriented. A major objective of this program is to enable students to solve problems. The aim is to prepare them methodologically and practically for the fast technological developments in the use of high throughput methods for data generation in biology, biotechnology and pharmacy.

The Master's program Bioinformatics combines courses from Bioinformatics, Computer Science and Life Sciences, and aims at enabling student to successfully work on biological problems in interdisciplinary teams using high-throughput techniques and bioinformatic methods. They will be introduced to efficient and modern methods e.g. to analyze, visualize, and store mass data, with a focus on their practical use and their use in research. The wide range of topics in Tübingen comprise, among others, genomics and transcriptomics, protein and drug design, microbiome analysis and systems biology.

In the department of a university where the focus is on research, it is a matter of course that latest scientific content is part of what is taught in the courses. This applies to the entire duration of the Master's program, and especially to the one-semester research project and the writing of the Master's thesis. Like computer science, bioinformatics relies heavily on external funding from co-operations with external partners, so research plays a major role, and the research results will naturally find their way into the course contents.

A special characteristic of bioinformatics is that students already may make important contributions by developing new algorithms, writing new software or participating in the evaluation of experimental data for research projects while writing their theses.

Knowledge of the German language and the English language (at least B2 level) is a prerequisite for applying for the Master's program Bioinformatics. By selecting the appropriate required elective modules from the available study areas, it is possible to complete the entire Master's program in English.

Qualification aims

The qualification aims of the Master's program Bioinformatics are based on those of the Bachelor's program Bioinformatics. In addition, holders of a Master's degree will have acquired the following:

1. They are familiar with sequencing, structural and systems bioinformatics, and are able to apply their knowledge to solve complex bioinformatic problems.

2. They are able to plan, perform and document bioinformatic research tasks, and present their results.

3. They are able to work on a bioinformatic problem using scientific methods, and develop and present solutions within a given time frame.

In addition and beyond the Bachelor's qualification aims, holders of a Master's degree Bioinformatics will have acquired the following knowledge and skills:

1. Thorough knowledge in Life Sciences.
2. Knowledge and skill to become quickly familiar with future methods and technologies in their own research area and with subfields of their research area.
3. Ability to successfully apply the acquired methods for determining and solving complex tasks in research and development both in industry and in research institutes, and to critically assess them and develop them further, if necessary.
4. Various technical and social skills (ability to abstract, system-analytical thinking, ability to work in a team, communication capabilities, international and intercultural experience etc.), preparing them for managerial functions.
5. They are not just capable of research and development work, but are also capable to take on managerial responsibilities in industry and administration.

Program design and Program organisation

The four-semester Master's program Bioinformatics is described in §3 (Studienaufbau - design of the program) of the specific information part in the exam regulations (Besonderer Teil) for the Master's program Bioinformatics and in the module handbook. Students will need to accumulate a total of 120 credit points. The fourth semester of this degree course is dedicated to the writing of a Master thesis. For information about course design and course organisation, see the introduction of the module handbook.

There are **three Master's program variants** - which variant applies, depends on the type of Bachelor's degree:

Variant A Students holding a Bachelor's degree in bioinformatics besitzen.

Variant B Students holding a degree in Biology or a related discipline. In the Master's program, students will acquire basic knowledge in computer science, and less credit points have to be accumulated in the life sciences.

Variant C Students holding a Bachelor's degree in computer science or a related discipline. In the Master's program, students will acquire basic knowledge in the life sciences, and less credit points have to be accumulated in computer science.

The appropriate variant will be assigned by the course director in agreement with the head of board of examiners during enrolment.

Examples of courses of study in Variant A can be found in Figure 1. As modules can be selected according to a students' interest, more varieties of what an individual student's course of study may look like are possible.

Study plan example Bioinformatics (variant A)

Semester 1	Semester 2	Semester 3	Semester 4
Sequence Bioinformatics	Structure and Systems Bioinformatics	Data Literacy	Master thesis
Structure-based Drug Design	Seminar: Metagenomics	Advanced Topics in Algorithmics	
Applied Statistics	Advanced Transcriptomics	Deep Learning	
Introduction to Comp. Neuroscience	Group Project Bioinformatics	Molecular and Cellular Proteomics	
Bioinformatics Tools	Neuronal Data Analysis	Concepts of Molecular Cell Biology	Colloquium
30 CP	Practical Transcriptomics	30 CP	30 CP

		ECTS
BIO-SEQ	Sequence Bioinformatics	9
BIO-STRUC	Structure and Systems Bioinformatics	9
BIO-SEM	Seminar Bioinformatics	3
BIO-GROUP	Group Project Bioinformatics	3
BIO-BIO	In-depth Bioinformatics	12
BIO-PRAK	Practical Bioinformatics	6
INFO-INFO	In-depth Computer Science	18
INFO-PRAK	Practical Computer Science	6
INFO-THEO	Theoretical Computer Science	6
BIO-LIFE	In-depth Life Sciences	18
Thesis	Bioinformatics Master thesis	30

Figure 1: Study plan example MSc Bioinformatics

Bioinformatics: Study areas and modules for all variants

The Master's program Bioinformatics consists of **study areas** and **modules** whose completion is compulsory. A study areas encompasses cognate modules which may be freely combined within the respective study area.

Modul Number: BIO-4110	**Modul title:** Sequence Bioinformatics		**Module Type:** Mandatory
ECTS	9		
Work load -Contact time -Self Study	Work load 270 h	Class time 90 h / 6 SWS	Self-Study 180 h
Duration	1 Semester		
Frequency	every winter semester		
Language	English		
Teaching forms	Lecture with Tutorials		
Modul content	This course covers sequence-based bioinformatics and evolution. The main topics are pairwise alignment, BLAST and related heuristics, suffix trees and their applications, sequence assembly, multiple alignment, hidden Markov models, gene finding, motif finding, machine learning methods, models of DNA evolution, phylogeny, whole genome phylogeny, computational methods in genomics, transcriptomics and metagenomics. During the course, each student will work on a project and will present the results in class.		
Qualification objectives	The first aim of this course is to introduce students to advanced concepts and methods in bioinformatics, focusing on algorithmic, computational and mathematical aspects. The second aim of this course is to enable students to apply advanced methods to problems in molecular biology and related fields. After taking this class, students will have a good understanding of the most important approaches in sequence-based bioinformatics, will know which problems can be addressed by the methods and will know how to apply such methods.		

Requirement for Credit Points / Grade

	Type of Class	Status	CH	ECTS	Type of Exam	Duration of Exam	Grade	Calculation of Module
Lecture	L	c	4	6	wt	90	j	100
Tutorials	T	c	2	3				

Requirement for participation	-
Lecturer	Huson

Modul Number: BIO-4120	**Modul title:** Structure and Systems Bioinformatics		**Module Type:** Mandatory
ECTS	9		
Work load -Contact time -Self Study	Work load 270 h	Class time 90 h / 6 SWS	Self-Study 180 h
Duration	1 Semester		
Frequency	every summer semester		
Language	English		
Teaching forms	Lecture, Tutorials		
Modul content	The course covers RNA structure and its prediction, basics of protein structure and their computational modeling, methods and concepts in systems biology, methods for the analysis of expression data and biological networks (concepts, inference, simulation). The course expands some of the topics already covered (in less detail) in the BSc course "Grundlagen der Bioinformatik' and specifically covers more advanced techniques, research-related applications.		
Qualification objectives	Students will be enabled to abstract and formalize problems in structure bioinformatics and computational systems biology. They can competently select appropriate methods and tools for structure and systems biology and are able to apply them to specific problems in the life sciences. They can independently solve research questions, particularly in a team. They have improved their language competence in English (understanding, writing, presenting).		

Requirement for Credit Points / Grade

	Type of Class	Status	CH	ECTS	Type of Exam	Duration of Exam	Grade	Calculation of Module
Lecture	L	c	4	6	wt	90	g	100
Tutorials	T	c	2	3				

Requirement for participation	-
Lecturer	Kohlbacher

Study area
BIO-SEM (3 ECTS)

Seminars from bioinformatics are creditable in this area of study

Qualification goals: Students are able to familiarize themselves with an assigned, challenging topic, to summarize, evaluate, classify and present concepts and algorithms of bioinformatics and applications of these to specific problems in the life sciences in a scientifically correct manner through systematic research, and to give a presentation on this topic to the instructor and other participants.

Responsible contact person for study area: Nieselt

Study area
BIO-BIO (15 ECTS)

Mandatory for this area is the group project (BIO-4103) following one of the two mandatory modules "Sequence Bioinformatics" (BIO-4110) or "Structure and Systems Bioinformatics" (BIO-4120). This area of study also includes modules for in-depth study of a wide variety of topics in bioinformatics. It is possible to include bioinformatics modules from the third year of the bachelor's degree in bioinformatics in this study area, as long as these have not yet been taken in the context of a preceding Bachelor's degree program. Furthermore, the choice of the research project (BIO-4998, see module catalogue) in bioinformatics is possible if the required prerequisites are fulfilled.

Responsible contact person for study area: Nieselt

Study area
BIO-PRAK (6 ECTS)

This study area includes the practical course in the area of bioinformatics.

Responsible contact person for study area: Nieselt

Study area
BIO-LIFE (Var A: 18, Var B and C: 12 ECTS)

This area of study allows for specialization in the life sciences. Modules can be selected from the 3rd year of the bachelor's program as well as the master's programs in the fields of biology, chemistry, pharmacy, and medicine, provided that they have not already been taken in the bachelor's program.

Responsible contact person for study area: Nieselt

Study area
INFO-INFO (Var A: 18, Var B: 9, Var C: 12 ECTS)

This study area provides a deeper understanding of computer science. Modules from the study area **INFO-INFO** of the master program Computer Science are eligible. The study area may also include modules from Bachelor's programs, provided those modules have not been completed in a previous Bachelor's program.

Responsible contact person for study area: Grust

Modul Number: BIO-4999	**Modul title:** Master's thesis incl. presentation		**Module Type:** Mandatory
ECTS	30		
Work load -Contact time -Self Study	Work load 900 h	Class time 60 h / 4 SWS	Self-Study 840 h
Duration	1 Semester		
Frequency	every Semester		
Language	English		
Teaching forms	Writing a Master's thesis and giving a presentation		
Modul content	The Master's thesis is the final stage of the Master's program, and consists of carrying out a project in bioinformatics, evaluating and processing the results obtained, and finally provide a written detailed presentation of these results. The results should contribute to scientific knowledge. In addition, students will give an oral presentation of their Master's thesis.		
Qualification objectives	Students will be able to independently complete, with supervision, a challenging task from a current research area based on the concepts and methods of bioinformatics of the relevant state of the art and develop new ideas for it, present the results in a scientifically correct manner and present them. Students • are able to become familiar with a current research issue within the specified time frame. They are able to apply scientific methods and present their results in a scientifically appropriate manner; • are able to independently handle a complex scientific issue, applying their knowledge of bioinformatics methods; • gain a deeper understanding of how to solve problems and are able to apply their knowledge about methods; • are able to work in teams in an international scientific setting; • are able to present and defend their research results to an audience in English.		

Requirement for Credit Points / Grade

	Type of Class	Status	CH	ECTS	Type of Exam	Duration of Exam	Grade	Calculation of Module
Master's thesis	tp	c	–	27	W		g	100
Defense	op	c	–	3				

Requirement for participation	
Lecturer	Lecturers of the Institute of Bioinformatics and Medical Informatics

Specific study areas variant A

Study area
INFO-PRAK (6 ECTS)

This area of study allows for a specialization in Practical Computer Science. It includes the modules of the study area **INFO-PRAK** of the Master's program in Computer Science.

Responsible contact person for study area: Grust

Study area
INFO-THEO (6 ECTS)

This area of study allows for an in-depth study in Theoretical Computer Science. It includes the modules of the study area **INFO-THEO** of the Master's program in Computer Science.

Responsible contact person for study area: Kaufmann

Specific study areas variant B

Study area
BIO-INFO (27 ECTS)

Among others, the following modules can be taken *Praktische Informatik 1: Deklarative Programmierung*, module number INFM1110, *Praktische Informatik 2: Imperative/Objektorientierte Programmierung*, module number INFM1120, and *Fundamentals of Bioinformatics*, module number BIOINFM2110 from the bachelor study program Bioinformatics as well as *Introduction to data structures and programming for life scientists*, module number BIO-1001, can be credited in order to enable students of variant B to obtain a post-qualification in fundamentals of computer science. Note that a number of modules are taught in German and that they are only eligible for students admitted as Var B. The exact determination of the modules for the study area is made in consultation with the person responsible for the study program.

Qualification goals: In this study area, basic knowledge, especially of programming and algorithms in computer science and bioinformatics, is taught.

Responsible contact person for study area: Nieselt

Specific study areas variant C

Study area
BIO-BASICLIFE (24 ECTS)

The modules in this area of study provide fundamental knowledge in the life sciences. The study area includes, among others, the modules *Biomoleküle und Zelle (BMZ)*, *Molekulare Biologie 1* and *Chemistry* of the bachelor's degree program in biology, in order to provide students of variant C with a post-graduate qualification in basic life sciences. The exact determination of the modules for the study area is made in consultation with the person responsible for the study program. Note that the courses in this study area are taught in German, and are not elligible for Variant A.

Responsible contact person for study area: Nieselt