Eberhard Karls Universität Tübingen

Bachelor Bioinformatics

List of Possible Units

English Translations From
the Official Unit List

October 15, 2019

Contents

Preface

Structure and Contents

This list describes all compulsory and a possible selection of compulsory elective units required for the Bachelor program Bioinformatics at the Eberhard Karls University Tübingen. A unit can be either a lecture, laboratory work, seminar, project, or a thesis.

Credits Points

The individual units are each assigned points complying with the European Credit Transfer System (ETCS). Credits are a quantitative measure of the time that has to be spend to complete a unit. They are coupled to the successful participation in courses and generation of academic achievments. Credits cover the actual teaching time in the courses (attendance time) as well as the time for the preparation and follow-up of the course material (self-study), the effort for the individual achievements (study achievements and exam preparation and for the bachelor thesis) as well as for internships.

Typically, 60 credits are awarded per academic year; 30 credits per semester. One ETCS point is earned for an effort of 30 hours in self-study, classrooms, or labs. The total workload should not exceed 900 hours in the semester, including the lecture-free period, or 1.800 hours in the academic year. This sums up to 45 weeks of 40 hours of work each.

Types of Units

Lectures Lectures are (if not described in more detail) a series of events in which the knowledge is mediated by a lecturer that presents topics to the student. Lectures are often accompanied by exercises in which the topics of the lecture are applied or deepened. In addition, there are compulsory presence or programming exercises in many events, in which subjects suitable for the lecture are dealt with under direct supervision. Grading usually results from the result of an exam (or oral exam) at the end of the lecture.

Seminars Seminars are (if not stated differently) a series of events in which students get familiar with an assigned topic and prepare a lecture to the lecturer and fellow students. As a rule, a written elaboration is also required. Coursework and examinations are typically provided in the form of a lecture, a written preparation and active participation in the discussions.

Laboratory or project work Laboratories or projects are (if not stated differently) events in which students work on an assignments independently or under supervision independently or in small groups. Students are usually evaluated based on their participation, the presentation of results, and written reports.

Grading

Each unit is typically completed with a grade determined by having a single exam. In exceptional cases, the grades may also be based on multiple tests. The evaluation is carried out by the lecturers of the respective unit. In accordance with the examination regulations, the module grades are weighted with their credit points into the final grade (Bachelor certificat grade).

1. Mathematics I

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

Topics are among others basics (mathematical argumentation; set theory; mappings and relations; natural numbers), real numbers, sequences and series, limits and growth of functions, differential and integral equations, Taylor expansion.

Qualification Goals

The students know the basics of analysis, which constitutes an important prerequisites for all domains of computer science. They have the ability to have (mathematically) correct arguments and presentations. By working in small groups, students have the ability to work together on problems and to critically evaluate other students' solutions. By engaging with strictly formal content and tools, argumentative accuracy is developed and stamina is strengthened.

Prerequisites for Attending

None

2. Mathematics II

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

Topics are among others algebra (groups, rings, fields, polynomial rings, minor classes and theorem of Lagrange) and linear algebra (vector spaces, linear maps and their matrix representation, rank of a matrix, basal changes, orthonormal bases, systems of linear equations and their solution by Gaussian algorithm, determinant, eigenvectors), as well as eigenvalues, orthogonal and symmetric matrices.

Qualification Goals

Students gain knowledge about algebraic structures and linear algebra and their applications in computer science. They are able to argue about abstract algebraic structures and can correctly apply the methods and algorithms of linear algebra for solving linear systems of equations and describing geometric facts. According to this module, the students have certainty in the formally correct mathematical reasoning and their presentation.

Prerequisites for Attending

Mathematics I recommended

3. Mathematics III

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

Topics are among others multidimensional analysis, Fourier series, optimization (extreme value problems under constraints, Lagrangian multipliers, algorithms in discrete and continuous optimization), topics from discrete mathematics such as number theory with applications in cryptology

Qualification Goals

The students gain knowledge in multidimensional analysis, number theory and their application in cryptology and optimization. After successfully finishing this module, they are able to establish relationships between different mathematic branches and name their importance for computer science.

Prerequisites for Attending

Mathematics I and II recommended

4. Stochastics

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	6
Workload:	180 h

Unit Content

Topics are among others probability spaces, random variables, distributions, independence, law of large numbers, central limit theorem, stochastic processes, stochastic models, sampling, estimation and testing.

Qualification Goals

The students have basic knowledge in probability theory and statistics. They are able to mathematically describe and analyze simple random phenomena. They may apply basic stochastic methods in computer science (e.g., bioinformatics, randomized algorithms).

Prerequisites for Attending

Mathematics I, II and III recommended

5. Computer Science I

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

Elements of programming, case discrimination and branching, compound and mixed data, accumulator programming, higher-order functions, interactive programs, recursive data structures and recursive functions, pattern matching, program design, draft recipes, reduction semantics, and program equivalence.

Qualification Goals

Students know design guidelines for the systematic construction of computer programs and can use them properly. They recognize the characteristics of the functional paradigm and can assess its strengths and limitations. They can structure problems, abstract them and then develop programs in a disciplined process. They can present their results in an understandable way and explain details of their solution path in specialist terminology

Prerequisites for Attending

None

6. Computer Science II

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

Modeling data, concept of classes, composition and union of class references, class hierarchies, object-oriented modeling and programming, functional methods, encapsulation of state, abstract classes, visibility and access rights, imperative methods, GUI programming, ModelView controller pattern, visitor pattern, debugging.

Qualification Goals

The students know methods and tools of object-oriented modeling and programming and can use them properly. They recognize the characteristics of stateful programming and understand the need to encapsulate state. Basic algorithms and data structures of computer science can be implemented and tested by the study imimperative style. They are ready to leverage their programming skills in subsequent larger projects.

Prerequisites for Attending

Computer Science I recommended

7. Theoretical Computer Science

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

Topics are among others Formal languages, Chomsky grammars and automata, computability, decidability and recursive enumeration, existence of undecidable problems, first set of Rice, complexity theory, time and space requirements, and NP completeness.

Qualification Goals

Students have the ability to execute the standard constructions from the domain of finite automata and regular expressions. They have an understanding of the phenomenon of unpredictability and frequency of occurrence, as well as a basic understanding of the notion of NP-completeness and its motivation.

Prerequisites for Attending

None

8. Algorithms and Data Structures

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

Introduction: Computational models, efficiency measures. Sorting methods: quicksort, heap sort, mergesort. Elementary data structures: lists, trees, graphs, dynamic search structures, hashing. Graph algorithms: screening, shortest paths, spanning trees. Algorithms on strings. Pattern search

Qualification Goals

The students have basic knowledge of basic data structures in computer science as well as algorithms for basic problems. In this content, they are capable of independent creative development of algorithms and data structures. The students know the interactions between data structures and algorithms and can apply these to specific examples. With the analytical techniques learned, they can evaluate simple algorithmic approaches according to their quality, efficiency and complexity.

Prerequisites for Attending

Basic knowledge of mathematics and programming

9. Software Project

Type of Unit:	compulsory
Teaching Method:	lecture and project work in small teams
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

Lecture Software Project: The module deals with the topics Introduction to Software Engineering, Programming in general, Project organization, Module concept, design by contract, Requirements specification. Specifications, design patterns (observer, model-view-controller, adapters, proxy), events and news, code reviews, unit tests and project documentation.

Project Work Software Project: The main part of this module is the project work. The students work in small teams on a programming project over the course of one semester. Every group is intensively supervised by a tutor, who gives feedback on the group's progress and helps to sort out issues. The identification of sub-tasks, scheduling, and implementation work is carried out by the group independently. After the semester ends, each group is graded based on the success and presentation of their project.

Qualification Goals

Students know methods and techniques for the design and programming of complex software in a team and can use them professionally. They can present their own contributions to the overall project clearly and competently and react flexibly to necessary changes. In addition, they can independently organize their project and determine the progress of the project. Students have acquired vocationally oriented, interdisciplinary skills. This may include, but is not limited to, presenting, organizing, communicating, problem-solving, and critically questioning.

Prerequisites for Attending

Computer Science I and II

10. Chemistry I: (General/Inorganic and Organic

Type of Unit:	compulsory
Teaching Method:	lecture, excercises and laboratory
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

Lecture General and Inorganic chemistry: atomic theory, stoichiometry, chemical formulas, chemical reaction equations, energy turnover in chemical reactions, electron structure of atoms, properties of atoms, chemical bonding, ionic bonding, covalent bonding, molecular structure, molecular orbitals, properties of gases, liquids and solids, solutions, chemical equilibrium, acids and bases, solubility product, redox reactions.

Lecture Organic Chemistry: Hybridization, atom and molecular orbitals, chemical equilibria, kinetics, classes of substances, functional groups, nomenclature, Substance properties, occurrence, synthesis and reactions, alkanes, alkenes, alkynes, isomerism, mesomerism, tautomerism, conformation, stereochemistry, haloalkanes, alcohols, ethers, carbonyl compounds, aldehydes, ketones, acetals, carboxylic acids, anhydrides, esters, amides, Nitriles, heterocycles, aromatics, radical, addition, elimination, substitution reactions, oxidation, reduction. The theoretical knowledge acquired in the lectures will then be intensified and applied in a compact practical course.

Qualification Goals

The students know basic principles and techniques of general, inorganic and organic chemistry. They know the practical application of these concepts. You have experience with chemical work in the laboratory and are familiar with laboratory safety.

Prerequisites for Attending

None

11. Biochemistry

Type of Unit:	compulsory
Teaching Method:	lecture
Teaching Language	German
ECTS Points:	3
Workload:	90 h

Unit Content

Basic knowledge of the structure of biologically relevant macromolecules as well as mechanistic and regulatory basic principles of metabolism (biosyntheses of sugars , complex carbohydrates, amino acids, proteins, fatty acids, lipids and the corresponding pathways) of eukaryotes. In addition, the basics of enzymology and modern biochemical techniques are taught.

Qualification Goals

The students know basic principles, important metabolic pathways, and important molecules of biochemistry.

Prerequisites for Attending

None

12. Physical Chemistry (Chemistry II)

Type of Unit:	compulsory
Teaching Method:	lecture, excercise and laboratory
Teaching Language	German
ECTS Points:	6
Workload:	180 h

Unit Content

Lecture Physical Chemistry: The basics of thermodynamics (state functions, laws, gas laws, equilibria, phase transitions and phase diagrams), electrochemistry (thermodynamics, EMF, Nernst equation, electrode types, transport processes), reaction kinetics (role in thermodynamics, reaction order, laws of time, equilibrium reactions), and the spectroscopy (electro-magnetic radiation, particles / wave, Termschemata, particles in the box, quantization, vibration, absorption, fluorescence) mediated.

Laboratory work: After the lecture period, selected experiments highlight the basic concepts of physical chemistry in two weeks of laboratory work.

Qualification Goals

Students know basic principles and techniques of physical chemistry. They know the practical application of these concepts. They have experience with chemical work in the laboratory and are familiar with laboratory safety.

Prerequisites for Attending

None

13. Biomolecules and Cell

Type of Unit:	compulsory
Teaching Method:	lecture and laboratory excercise
Teaching Language	German
ECTS Points:	6
Workload:	180h

Unit Content

Lecture Biomolecules and Cell: The lecture gives a brief outline of the biochemical basis of life, introduces the basic structures of eukaryotic and prokaryotic cells and describes the principles of cell growth and proliferation. It explains the molecular basis of genetic information, the flow of genetic information from DNA to protein and the consequences of mutation and recombination. In addition to an insight into the basics of bacteria and viral genetics, an introduction to genetic engineering is given.

Laboratory Excercise Biomolecules and Cell: The practical part of Biomolecules and Cell deals with the following topics: Construction and detection of DNA and proteins; microscopy; basics of cell biology; layout and organells of eukaryotic cells; introduction to genetics.

Qualification Goals

The students can observe and reproduce biological phenomena in detail, identify and describe organisms, create scientific records, analyze and interpret measurement and test results, adequately select subject-specific techniques, document measurement and test results, and communicate biological issues. They have proven to understand scientific contexts, work critically and develop a sound professional judgment. During the laboratory excercise they have worked in a team.

Prerequisites for Attending

None

14. Molecular Biology I

Type of Unit:	compulsory
Teaching Method:	lecture
Teaching Language	German
ECTS Points:	6
Workload:	180h

Unit Content

Lecture Molecular Biology I (Cell biology and Genetics): The lecture presents the molecular mechanisms of cell proliferation, cell death, and cell motility, and addresses the more complex functions of cells for metabolism, differentiation, signaling, and development. It deals with the organization of genes in the genome, selected mechanisms of gene regulation and the principles of developmental genetics. It explains the methods used by molecular cell biology and molecular genetics.

Qualification Goals

The students can observe and reproduce biological phenomena in detail, identify and describe organisms, create scientific records, analyze and interpret measurement and test results, adequately select subject-specific techniques, document measurement and test results, and communicate biological issues. They have proven to understand scientific contexts, work critically and develop a sound professional judgment. During the laboratory excercise they have worked in a team.

Prerequisites for Attending

None

15. Animal Physiology (Neurobiology)

Type of Unit:	compulsory
Teaching Method:	lecture and laboratory
Teaching Language	German
ECTS Points:	9
Workload:	270h

Unit Content

Lecture Animal Physiology (Neurobiology): For animals and humans, connections between structure and function at the level of tissues, organs and complex organ systems and their relevance for the emergence of behavior in animals are presented. The focus is on general principles of physiology. The question of the adaptation value of certain construction-function relationships is also posed in comparative considerations. The mediation of specific physiological learning approaches takes precedence over the mediation of matter following to the motto: teaching key concepts is better than touching a broad but shallow spectrum.

Laboratory Excercise Biomolecules and Cell: The Animal Physiological Course for Bioinformatics aims to experimentally measure the electrophysical principals of animal life. Topics include: Reflexes, transmission of SAPs through nerves, muscle activity, heartbeat.

Qualification Goals

The students know the basics of animal physiology. In practical experiments, they have acquired basic laboratory skills. Since the laboratory is conducted in group, the students extend their constructive criticism and discussion skills.

Prerequisites for Attending

None

16. Bioinformatics I: Introduction to Bioinformatics

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	3
Workload:	90 h

Unit Content

The course provides an insight into bioinformatics. For this purpose, selected topics of bioinformatics will be briefly presented in the lecture. It will be put into perspective, how the modules from the first two years of bioinformatics will prove useful. The topics are presented by different lecturers at the university of tübingen to cover the entire breadth of bioinformatics. The topics are reviewed and summarized by the students in exercises. A selection of recurring topics is:

1. What is bioinformatics?
2. From DNA to the database: sequencing, assembly,
3. Darwin's heirs: Genome-based genealogies
4. Metagenomics - from a handful of earth
5. Molecular Machines - Protein structures and their function
6. Designer Drugs - active ingredients from the computer
7. Vaccinations against cancer - bioinformatics in vaccine design
8. Analysis of biological networks
9. It's hip to chip - from microarrays to personalized medicine
10. The language of proteins - evolution of conserved protein structures.

Qualification Goals

The students have gained an overview of the major branches of bioinformatics, such as sequencing, phylogeny, metagenomics and drug design, know the how the subdomains intertwine, and can classify them. The interest of the students in the basic events will be strengthened and the motivation for the professional breadth of the study will be conveyed.

Prerequisites for Attending

None

17. Bioinformatics II: Algorithms

Type of Unit:	compulsory
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	9
Workload:	270 h

Unit Content

The lecture focuses on the fundamental algorithms of bioinformatics. In the accompanying exercises, the student should gain practical experience in the application of standard tools of bioinformatics to life sciences questions, but on the other hand, the writing of own computer programs should be practiced. Great emphasis is placed on deepening the acquired knowledge in accompanying exercises in small groups. This compulsory module is the basis of all other bioinformatics events. Contents of the lecture are: Pairwise alignments, multiple alignments, BLAST, phylogeny, Markov models, machine learning, RNA secondary structure, protein secondary structure, protein-tertiary structure, microarrays, sequencing.

Qualification Goals

The students know basic concepts and methods of bioinformatics as well as mathematical methods for the modeling of biological problems. By dealing with typical bioinformatic questions, the students are prepared to cope with the situations that arise in their daily work. They can recognize biological problems and describe, abstract and then solve them as bioinformatic problems.

Prerequisites for Attending

None

18. Bioinformatics II: Seminar Metagenomics

Type of Unit:	compulsory elective
Teaching Method:	seminar
Teaching Language	English
ECTS Points:	3
Workload:	90 h

Unit Content

Possible topics are basics of sequencing, basics of genomics, basics of genome comparison, basics of metagenomic, basics of metagenome comparison. A publication from one of these topics is selected and presented to the fellow students.

Qualification Goals

The students have expanded their skills in presenting, organizing and communicating by working with scientific literature. In particular, they are able to communicate in an understandable way about the basic professional content of bioinformatics. They have expanded their basic knowledge of bioinformatics by means of scientific publications and textbooks, and can summarize this verbally in their own words.

Prerequisites for Attending

Bioinformatics I, II

19. Introduction to Internet Technologies

Type of Unit:	compulsory elective
Teaching Method:	lecture and excercise
Teaching Language	German
ECTS Points:	6
Workload:	180 h

Unit Content

The Lecture Introduction to Internet Technologies teaches the basics of client-server communication, the building blocks of static web pages, client-side dynamic content with JavaScript, server-side dynamic web page rendering with Python/Ruby cgi as well as PHP. Design and programming tasks as part of the exercises are ment to deepen the concepts tought in the lecture.

Qualification Goals

The students are familiar with current issues and research fields of informatics, have in-depth theoretical, practical and technical knowledge of selected topics, have gotten acquainted with different analytic and methodological approaches of computer science, had the opportunity to improve their communication skills and their ability to work in small groups.

Prerequisites for Attending

None

20. Structure-based Drug Design

Type of Unit:	compulsory elective
Teaching Method:	lecture and excercise
Teaching Language	German/English
ECTS Points:	6
Workload:	180 h

Unit Content

The course teaches pharmaceutical basics such as pharmacodynamics, protein-protein interactions, and molecular dynamics. Computational screening procedures to identify LEAD structures with force fields and in-silico HTS methods are introduced. These techniques are applied in excercises and a group project, where ligands for a receptor molecule have to be identified via docking.

Qualification Goals

The students have advanced knowledge in bioinformatics and can apply it. The qualifications attained in the relevant events for this module (e.g. Structure-based Drug Design) allow students to study a bioinformatics topic in greater detail and thus develop their professional knowledge. In addition, they have had the opportunity to improve their communication skills and their ability to work in small groups.

Prerequisites for Attending

Bioinformatics II

21. Introduction to Immunology

Type of Unit:	compulsory elective
Teaching Method:	lecture and seminar
Teaching Language	German/English
ECTS Points:	6
Workload:	180 h

Unit Content

Lecture Introduction to Immunology (3 ECTS) Topics are the basics of immunology: Involved cells, development and differentiation, effectors, information transfer, infection control, molecular recognition mechanisms. It gives an overview of the most important cell populations of the immune system, effector functions, plasticity and differentiation processes, overview of immunologically relevant molecular interactions.

Seminar Milestones of Immunology (3 ECTS) The aim of the seminar is to record, discuss and contextualise findings of immunology and their influence on today's research and medicine. In the first seminar lesson students will select an article from a topic overview for their presentation and discuss their structure. Then the students present and discuss 1-2 articles weekly in the seminar (presentation 30 min and subsequent discussion 10 min). The discussion round will be conducted alternately by a seminar participant. The aim of the debriefing is to give the student feedback on his presentation and to question the article critically and constructively. Presentation in German or English.

Qualification Goals

The students have advanced their knowledge in a field of life sciences and can apply it. They have successfully presented and presented an immunological publication.

Prerequisites for Attending

Animal Physiology (Neurobiology), Biomolecules and Cell, Chemistry I, Physical Chemistry (Chemistry II)

22. Microarray Bioinformatics

Type of Unit:	compulsory elective
Teaching Method:	lecture and excercise
Teaching Language	German/English
ECTS Points:	6
Workload:	180 h

Unit Content

Fundamentals of the technologies for the expression analysis esp. of Microarrays. Topics are among others: Algorithms for microarray design, image analysis, normalization methods, dimension reduction by principal component analysis, clustering, statistical hypothesis testing, and classification techniques.

Qualification Goals

Methods and acquired skills of the various modules of the first two years of study (for example, algorithms, statistical methods, programming skills) are applied to concrete questions of an important topic of bioinformatics. The students analyze microarray experiments and learn how to program with the scripting language R. They understand the connections between the different aspects of what has been learned so far and can apply them to practical problems. They are able to actively capture problems, discuss them critically and develop solutions. This increases the methodological competence of the student.

Prerequisites for Attending

Bioinformatics II and Stochastics

23. Cross Disciplinary Competences

Type of Unit:	compulsory elective
Teaching Method:	any
Teaching Language	German
ECTS Points:	3
Workload:	90 h

Unit Content

The module provides interdisciplinary vocational field-oriented competences. These are acquired in selected events. The aim of the events is to support the students in their professional orientation and to prepare them for a professional career start. All events (except sport) for which credits (ECTS) are clearly stated can be taken as events at the University of Tübingen. These include u.a. besides courses offered in computer science, etc. Courses of the Career Service of the University of Tübingen, the Specialist Language Center, the Studium Professionale, the arts courses, the GIS courses of the Geosciences Department, and the Rhetoric Courses of the Faculty of Philosophy. Due to the high level of interdisciplinary flexibility of the events that can be covered in this module, the services provided in the respective events will be examined separately, depending on the format.

Example Compulsory Elective Units: Lecture IT Law, Lecture Unix/Linux, Course Comic Drawing

Qualification Goals

The students have acquired job-oriented interdisciplinary skills. This may include, for example, presenting, organizing, communicating, problem-solving skills and critical questioning.

Prerequisites for Attending

None

24. Bachelor Thesis

Type of Unit:	compulsory elective
Teaching Method:	Independent research, scientific writing, and preparing a presentation
Teaching Language	German/English
ECTS Points:	15
Workload:	450 h

Unit Content

The unit provides an insight to working scientifically on a chosen/assigned research question. The topic of the thesis is to be taken from the field of bioinformatics.

Qualification Goals

The students can research and write about a topic in bioinformatics. They are capable of communicating their findings as a presentation.

Prerequisites for Attending

None