



**066/875**

# Curriculum

for the Master of Science in

# ***BIOINFORMATICS***

## *CONTENTS*

§ 1 Qualification profile .....	3
§ 2 Admission requirements .....	4
§ 3 Duration and number of credits .....	4
§ 4 Types of courses .....	4
§ 5 Structure and contents of the modules .....	5
§ 6 Master thesis .....	12
§ 7 Examination regulations .....	12
§ 8 Academic degree .....	13
§ 9 Effective date .....	13
§ 10 Regulations for students entering to this curriculum .....	13

## § 1 Qualification profile

(1) Bioinformatics is a relative new, interdisciplinary research area and forms the interface between life sciences and computer science. Bioinformatics is known as a key technology of one of the fundamental achievements of mankind, the decoding of the human genome. These days bioinformatics is established as an independent education and scientific discipline. Data from life science, medicine, drug design and pharmacy industry is managed, visualized, analyzed, interpreted, compared to one another, and simulated on basis of bioinformatics methods. Bioinformatics further utilizes and develops methods and techniques from computer science in order to solve tasks from biology, chemistry, physics, medicine, or mathematics.

(2) Various job profiles exist for masters in bioinformatics, where they build the connection between life science and IT experts. On the one hand they may work in pharmacy, chemistry, and food industry or in biotech companies, on the other hand they may be employed in software companies producing software for experts in biology, physics, medicine or chemistry. The scope of duties of masters in bioinformatics is manifold, e.g. they may be experts in databases, molecular dynamics simulations, machine learning and pattern recognition, or in algorithm design.

(3) Masters in bioinformatics use their social competences to quickly comprehend the problems of life science experts and thereafter efficiently apply and adapt methods and techniques from computer science for solving those problems. Further, due to their interdisciplinary experiences, they are able to combine computer science with areas which are not associated with life sciences. Masters in bioinformatics are educated to apply methods of computer science in a responsible and critical way and to challenge new developments.

(4) Education in bioinformatics aims at developing competency in problem solving. A master in bioinformatics has knowledge and abilities in the following areas:

1. **FUNDAMENTAL KNOWLEDGE:** Fundamental knowledge in computer science, biology, biochemistry, biophysics, mathematics as well as in the central subjects of bioinformatics.
2. **SPECIAL KNOWLEDGE:** Specialized courses and current topics of bioinformatics. The specialized courses are both in computer science and in biology, mathematics, chemistry or physics.
3. **METHODS:** Theoretical and practical knowledge of bioinformatic methods. Especially analysis of problems, analytical and logical thinking, understanding and representation of complex dependencies and structures. Masters in bioinformatics know how to use and how to apply the methods and techniques of bioinformatics and how to access and use the public available software and data base resources adapted to the problem at hand.
4. **INNOVATION:** Readiness and ability to scientific research as well as to independently and systematically advance bioinformatics.
5. **CONTINUING EDUCATION:** Readiness and ability to independently learn further knowledge, especially training the handling of new methods and techniques of bioinformatics. Specialization in specific subjects and following new developments.
6. **INTERNATIONALITY:** Supported visits of foreign countries and exchange programs and courses in foreign languages. Solid knowledge of the English colloquial and technical language in order to communicate with international partner institutions.

7. CRITICAL FACULTY: Critical and responsible use of the methods and techniques of bioinformatics regarding questions of ethic and of social and environmental effects of new technologies.
8. SOCIAL COMPETENCE: Ability to work in a team, willingness and ability to cooperate, management capabilities, and expertise in presenting and moderating.

## **§ 2 Admission requirements**

(1) According to § 54 para. 2 UG 2002 the master study Bioinformatics belongs to the group of natural science studies. Admission for the master in bioinformatics is a bachelor or master degree from a university or university of applied sciences with a technical eligibility for the master study course in bioinformatics.

(2) The technical eligibility holds if the applicant has a bachelor or master degree in computer science, mathematics or in a similar subject.

(3) The technical eligibility holds if the applicant has a bachelor or master degree in biology, chemistry, physics or a similar subject and if the applicant documents the admission requirements given below. Basic programming knowledge must be documented at the beginning of Module 13 (cf. § 5). For a bachelor or master in chemistry or a similar subject the requirements are molecular biological and biochemical basics according to the courses „Molecular biology of the cell I “ and the course „Introduction into instrumental analytics for Life-Sciences “ which must be documented at the begin of Module 9 (cf. § 5). For a bachelor or master in physics or a similar subject the requirements are biochemical basics according to the course „Chemistry for Physicist II“ which have to be documented at the begin of Module 9 (cf. § 5).

(4) Sufficient knowledge of the English language (corresponding to level B2 of the Common European Framework of Reference for Languages, CEFR) is recommended.

## **§ 3 Duration and number of credits**

(1) The master study extends over 4 semesters.

(2) The master study must comply with 120 European Credit Transfer System points, abbreviated ECTS, and the teaching effort is 62 semester hours, abbreviated SSt. In compliance with the European System for crediting study performance (European Credit Transfer System - ECTS) credits are given for the individual courses. With these credits the relative share of the work quota associated with an individual course is defined, in relation to a total work quota of 30 credits per semester. The credits therefore represent the quantitative work share which must be spent on each course in proportion to the required study quota for the successful completion of studies. They consider lectures, seminars, exercises, practical work, tutorials, private studies at the university and at home, the assessment of scientific work, as well as examinations and other forms of performance assessment.

## **§ 4 Types of courses**

(1) Types of courses:

1. *Lectures (VO)* are courses which introduce students into the fields and methodology of

the study and impart knowledge in a given subject.

2. *Exercises (UE)* are courses which should reinforce subjects presented in the corresponding lecture by carrying out practical and concrete exercises. Marking for exercises is based on continuous assessment of work by students.
3. *Combined Courses (KV) or lectures with exercises (VU)* are courses which can consist of any number of theoretical or practical parts which can be interlocked according to didactic points of view.
4. *Practical Training (PR)* should complete a student's practical skills. Practical Trainings have similar goals to exercises. However, they can be held independently of lectures and should especially encourage team oriented work. Marking for practical training is based on continuous assessment of student's work. *Project practical* is a special practical training which focuses on small practical or research projects including all necessary steps from the beginning to the end of a project. The project practical requires a written paper to document the project and its results. The project practical serves to train students on solving problems of practical bioinformatics where the students work in teams and apply or develop bioinformatics software. Marking is based on continuous assessment of work by students.
5. *Seminars (SE)* are courses involving collaboration between students. Marking of seminars is based on continuous assessment of student's work and especially on their own preparation of talks, including written seminar papers, and on their participation in discussions about talks of other students. Master seminars are seminars which should prepare students for their master thesis and should support them in writing their master thesis.

(2) Courses can be hold in English. Thesis or other papers of the curriculum can be written in English or another foreign language if the supervisor of the course or thesis agrees to that.

(3) *Number of applicants per course.* Bearing in mind the suitable student capacity, the relevant dean, in collaboration with the study commission, has to arrange a limited number of parallel courses, especially for course types where an exam is imminent. The total number of applicants for exercises, combined courses, and practical training should be 35 and for seminars 20. In courses with a limit on the number of students the admission is done according to the direct assignment policy (Direktzuteilungsverfahren).

## § 5 Structure and contents of the modules

(1) Thematically related courses which are self-contained units of study constitute *modules*. One course can only be credited for *one* module. The courses of a module can only be attended if the module's admission requirements are fulfilled. A module may consist of one course or different courses.

(2) Assignment of courses to modules:

The assignment of courses to modules is given in appendix A.

(3) Types of modules and their assignment to semesters:

1. *Bridge modules* contain courses in basic areas of bioinformatics - computer science, mathematics and biology/chemistry - which have to be attended in the *leveling phase* of the first semester depending on the student's earlier bachelor or master studies in order to bring them to the same level (cf. para. (4)).
2. *Compulsory modules* contain compulsory bioinformatics courses (especially in the second

semester) as well as courses addressing the topics "ethic" and "gender studies".

3. *Elective modules* contain elective courses (in the third semester) which serve the students to specialize in bioinformatics, computer science, physics, chemistry or mathematics topics which are closely related to bioinformatics.
4. *Free elective modules* contain free elective courses for the personal education (in the first, second, and fourth semester).

(4) Figure 1 shows an overview of the structure of the study and the modules (M1 - M17) where their extent is given in ECTS/SSt and their assignment to semesters.

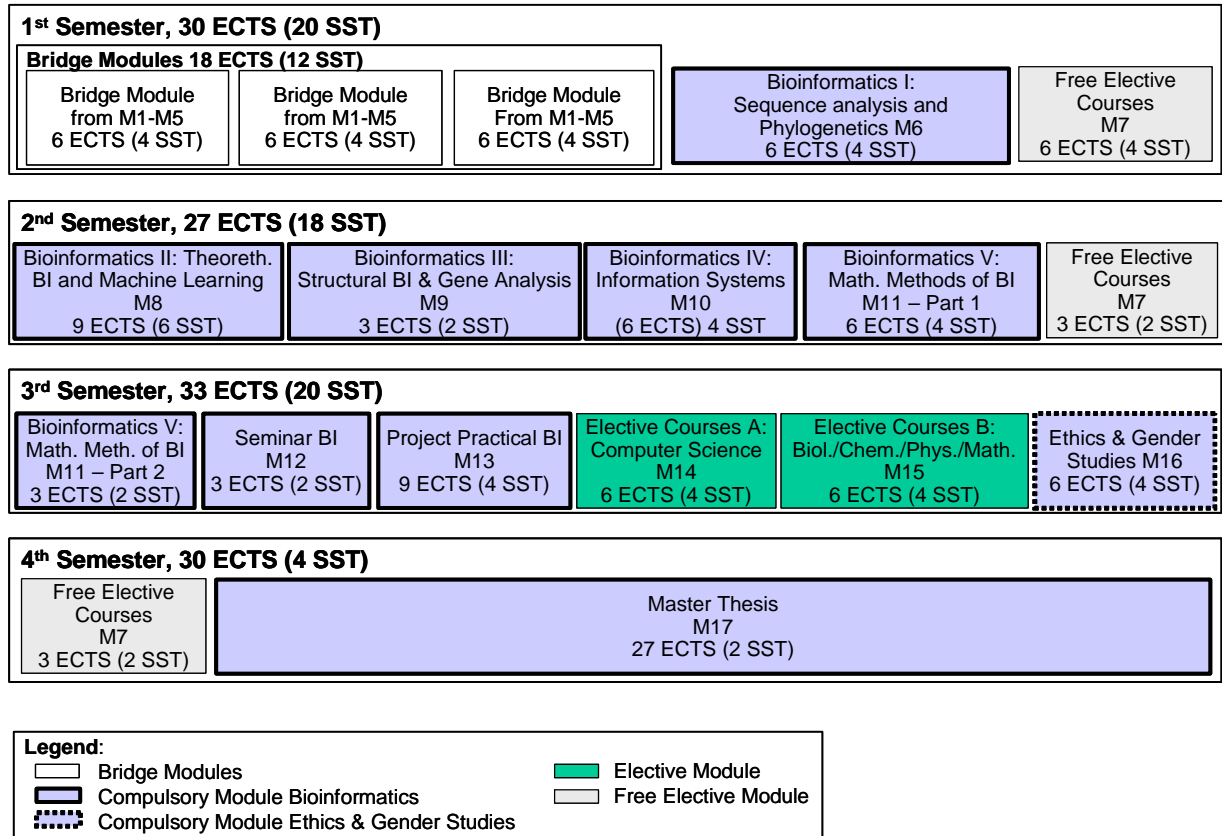


Figure 1: Structure of study and modules

(5) Leveling phase and bridge modules:

The assignment of the bridge modules during the leveling phase according to the earlier graduation is shown in Figure 2. Bridge modules from biology/chemistry, computer science and mathematics must be attended in the leveling phase according to the bachelor or master in computer science, mathematics, chemistry, physics and biology where the bridge courses amount to 18 ECTS.

Bridge module		Bachelor or Master degree				
		Computer Science	Mathematics	Chemistry	Physics	Biology
Biology/ Chemistry	M1: Basics of molecular biology	4,5	4,5		4,5	
	M2: Basics of biochemistry	7,5	7,5		4,5*	
Computer Science	M3: Basics of algorithms and data structures			6		6
	M4: Basics of information systems		6	6	6	6
Mathematics	M5: Basics of mathematics	6		6	3*	6
		18 ECTS	18 ECTS	18 ECTS	18 ECTS	18 ECTS

\* Only a part of this module must be attended (cf. appendix A).

Figure 2: Leveling phase - Assignment of bridge modules to bachelor or master grades in different fields

(6) Description of the modules M1-M17:

**Module 1: *Basics of molecular biology***

*Type:* Bridge module

*Contents:* DNA, RNA, Transcription, Translation, Genetic Code, Promoter, Protein folding, Gene regulation, etc.

*Admission requirements:* none

*ECTS (SSt):* 4,5 (3)

*Recommended semester:* 1

**Module 2: *Basics of biochemistry***

*Type:* Bridge module

*Contents:* Purification, Molecular forces, Secondary / Tertiary / quaternary structure, Folding, Molecular dynamics, instrumental analytics (NMR spectroscopy, mass spectrometry, infrared spectrometry, fluorescence microscopy, chromatometry, x-ray crystallography), Micro array, Protein array, etc.

*Admission requirements:* none

*ECTS (SSt):* 7,5 (5)  
*Recommended semester:* 1

### **Module 3: *Basics of algorithms and data structures***

*Type:* Bridge module  
*Contents:* Dynamical data structures (lists, trees, graphs, stacks, queues), sorting algorithms, graph algorithms (Dijkstra), string comparison, knowledge representation, inferring with fuzzy knowledge and noise data, basics of machine learning, decision trees, neural networks, etc.  
*Admission requirements:* none  
*ECTS (SSt):* 6 (4)  
*Recommended semester:* 1

### **Module 4: *Basics of information systems***

*Type:* Bridge module  
*Contents:* database design, concept of relational databases, SQL, XML, etc.  
*Admission requirements:* none  
*ECTS (SSt):* 6 (4)  
*Recommended semester:* 1

### **Module 5: *Basics of mathematics***

*Type:* Bridge module  
*Contents:* Statistics (test theory, estimation theory, variance analysis, regression), numerical und symbolic methods (calculus, optimization) using Matlab, etc.  
*Admission requirements:* none  
*ECTS (SSt):* 6 (4)  
*Recommended semester:* 1

### **Module 6: *Bioinformatics I: Sequence analysis and phylogenetics***

*Type:* Compulsory module  
*Contents:* Pairwise alignment, multiple alignment, alignment statistics, homology modeling, phylogenetic trees, etc.  
*Admission requirements:* none  
*ECTS (SSt):* 6 (4)  
*Recommended semester:* 1

### **Module 7: Free elective courses**

<i>Type:</i>	Free elective module
<i>Contents:</i>	free selectable
<i>Admission requirements:</i>	none
<i>ECTS (SSt):</i>	12 (8)
<i>Recommended semester:</i>	1 (6 ECTS, 4 SSt) 2 (3 ECTS, 2 SSt) 4 (3 ECTS, 2 SSt)

### **Module 8: Bioinformatics II: Theoretical Bioinformatics and machine learning**

<i>Type:</i>	Compulsory module
<i>Contents:</i>	classification, regression, kernels, sequence analysis, neuronal nets, support vector machines, hidden Markov models, clustering, principal component analysis, independent component analysis, projection methods, error models, optimization techniques, regularization, Bayes approach, hyper-parameter optimization, feature selection, statistical learning theory, etc.
<i>Admission requirements:</i>	M3-M5 (according to admission requirements)
<i>ECTS (SSt):</i>	9 (6)
<i>Recommended semester:</i>	2

### **Module 9: Bioinformatics III: Structural Bioinformatics und gene analysis**

<i>Type:</i>	Compulsory module
<i>Contents:</i>	Data bases for 3D structures, Molecular Viewers, Structure prediction, Threading, ab initio prediction, molecular dynamics, structural alignments, protein folding, protein classification, Motif search, gene expression profiles, Microarray technique, Single Nucleotide Polymorphism, Gene selection, Epigenomics, Pathways, etc.
<i>Admission requirements:</i>	M1-M6 and admission requirements (cf. § 2 (3))
<i>ECTS (SSt):</i>	3 (2)
<i>Recommended semester:</i>	2

### **Module 10: Bioinformatics IV: Information systems**

<i>Type:</i>	Compulsory module
<i>Contents:</i>	Biological Data bases, design techniques, object-relational concepts, structured (SQL-based) and unstructured (IR-based) Query techniques, Data Warehousing and Data

Mining, optimization techniques, Architectures for data integration, data quality, semantic integration, ontologies, XML-techniques, etc.

*Admission requirements:* M1-M6 (according to admission requirements)

*ECTS (SSt):* 6 (4)

*Recommended semester:* 2

### **Module 11: *Bioinformatics V: Mathematical methods of Bioinformatics***

*Type:* Compulsory module

*Contents:* Numerical Methods in Biology (calculus, ordinary differential equations, inverse problems, basics of partial differential equations, etc. - 4 KV with exercises at the computer), algebraic and discrete methods in Biology (algorithmic algebra, algorithms for strings and sequences, discrete methods, etc. - 2 KV with exercises at the computer, e.g. with Mathematica).

*Admission requirements:* M1-M6 (according to admission requirements)

*ECTS (SSt):* 9 (6)

*Recommended semester:* 2 (6 ECTS, 4 SSt)  
3 (3 ECTS, 2 SSt)

### **Module 12: *Seminar Bioinformatics***

*Type:* Compulsory module

*Contents:* In detail treatment of a specific topic in bioinformatics. Original literature is analyzed; results are verified, final presentation in a talk or with a poster.

*Admission requirements:* M6, M8-M10

*ECTS (SSt):* 3 (2)

*Recommended semester:* 3

### **Module 13: *Project practical Bioinformatics***

*Type:* Compulsory module

*Contents:* A task in the field of bioinformatics will be analyzed and solved. Typically the project is made in groups. After assigning the tasks, the single projects are presented by the students. Thereafter the tasks will be solved, where typically software is written. Finally, the results are presented both in a talk and as a report.

*Admission requirements:* M6, M8-M10 and admission requirements (cf. § 2 (3))

*ECTS (SSt):* 9 (4)

*Recommended semester:* 3

#### **Module 14: Elective courses A: Computer Science**

*Type:* Elective module

*Contents:* Specialization in a computer science subject

*Admission requirements:* M3-M4

*ECTS (SSt):* 6 (4)

*Recommended semester:* 3

#### **Module 15: Elective courses B: Biology/Chemistry/Physics/Mathematics**

*Type:* Elective module

*Contents:* Specialization in a subject from biology, chemistry, physics, or mathematics

*Admission requirements:* M1-M2, M5 (according to admission requirements)

*ECTS (SSt):* 6 (4)

*Recommended semester:* 3

#### **Module 16: Ethics and Gender Studies**

*Type:* Compulsory module

*Contents:* Ethics: critical and responsible application of molecular biological methods and molecular biological diagnostics and therapy selection, assessment of the social and environmental effects of new technologies  
Gender Studies: Definition/Construction of Gender/Sex - social-cultural (gender) versus anatomic/physical/-biological (sex), Gender in science and technology in methodology and epistemology, biological/medical definition of gender and social influences and impacts, situations of women/man in science and technology (diverse historical/cultural mechanism of including and excluding)

*Admission requirements:* none

*ECTS (SSt):* 6 (4)

*Recommended semester:* 3

#### **Module 17: Master thesis**

*Type:* Compulsory module

*Contents:* The written thesis serves as evidence for the ability of scientific work in the field of bioinformatics. This module

consists of the written master thesis (22 ECTS), an accompanying seminar (3 ECTS) and the master examination (2 ECTS)

*Admission requirements:* M6, M8-M11

*ECTS (SSt):* 27 (2)

*Recommended semester:* 4

## § 6 Master thesis

(1) The master thesis is a module (M17) and consists of the master thesis itself, an accompanying seminar and the master examination.

(2) The topic of the master thesis is taken from the contents of module M6 or modules M8-M11. The topic is closely related to bioinformatics where topics spanning over different modules are possible.

(3) The last semester serves to make the master thesis. The master thesis is credited with 24 ECTS.

(4) The master thesis is accompanied by a master seminar which extent is 3 ECTS (2 SSt).

(5) During the master examination (2 ECTS) the student has to defend the master thesis and has to display a profound knowledge of the according subject (cf. § 7 (3)).

(6) The master thesis is evaluated through a review.

## § 7 Examination regulations

### *(1) Examinations of course*

There must be written or oral examinations for course lectures (VO). Study success in exercises (UE), seminars (SE) and practical training (PR) is judged/evaluated by accompanying supervision and a concluding review. The examination procedure for combined courses (KV) and lectures with exercises (VU) can be selected by the course organizer according to the character of the course. A module has been completed successfully if all examinations belonging to this subject have been completed successfully and the required ECTS are acquired.

### *(2) Admission requirements for attending the master examination*

Admission requirements for attending the master examination are the successful completion of the modules M6-M17 as well as the bridge modules which are assigned to the bachelor or master of the earlier study.

### *(3) Master examination*

The master examination is an oral examination which consists of:

1. Defense of the master thesis in connection with an examination of the attended courses which are contextually related to the topic of the master thesis.
2. Examination with contents from module M6 and modules M8-M11. The topics of the examination stems from the contents of the according courses where for the extent of the examination the examination in item (1) has to be regarded.

This examination focuses on the overview over bioinformatics topics and on recognizing and utilizing connections between different topics in bioinformatics and related subjects.

## § 8 Academic degree

Due to the successfully passed master examination the academic degree „Master of Science in Bioinformatics“ (abbreviated „MSc“ or “MSc (JKU)”) will be awarded.

## § 9 Effective date

The curriculum becomes effective with 1. October 2006.

## § 10 Regulations for students entering to this curriculum

Courses of the master curriculum 2006 are equivalent to courses of the master curriculum 2009 if they have the same name or if they are listed in Table 1. Table 1 becomes effective with 1. October 2009.

Table 1: *Equivalent courses*

Courses of the curriculum 2006	Courses of the curriculum 2009
Artificial Intelligence	Artificial Intelligence
Software Engineering 1	Software Engineering
Software Engineering 2	Software Architectures
Parallel Computing	Computer Architecture 2
Information Systems 3	Security Models in Information Systems
Information Retrieval and Hypermedia Techniques	Web Information Retrieval
Introduction into instrumental analytics for Life-Sciences	Introduction: instrumental analytics for Life-Sciences <i>and</i> Introduction I to General Chemistry
Gender studies Bioinformatics	Ethics and Gender Studies

Courses of the master curriculum 2009 are equivalent to courses of the master curriculum 2011 if they have the same name or if they are listed in Table 1. Table 1 becomes effective with 1. October 2011.

Table 2: *Equivalent courses*

Courses of the curriculum 2009	Courses of the curriculum 2011
Introduction I to General Chemistry	Basics in Chemistry for Bioinformatics
Statistical methods	Statistical Signal Processing
Numerical and symbolical methods for Bioinformatics	Numerical and symbolical methods for Bioinformatics

## Appendix A: Assignment of courses to modules

In the following the courses for each module are listed. Further, Figure 3 shows for the bridge modules (M1-M5) the courses which must be attended and, therefore, concretizes Figure 2.

Bridge Module		Bachelor or Master degree				
		Computer Science	Mathematics	Chemistry	Physics	Biology
Biology/ Chemistry	<b>M1: Basics of molecular biology</b> <ul style="list-style-type: none"> <li>▪ Molecular biology of the cell I</li> </ul>	4,5	4,5		4,5	
	<b>M2: Basics of biochemistry</b> <ul style="list-style-type: none"> <li>▪ Introduction: instrumental analytics for Life-Sciences</li> <li>▪ Chemistry for Physicist II</li> <li>▪ Basics in Chemistry for Bioinformatics</li> </ul>	3 3 1,5	3 3 1,5		3  1,5	
Computer Science	<b>M3: Basics of algorithms and data structures</b> <ul style="list-style-type: none"> <li>▪ Algorithms and Data Structures 2</li> <li>▪ Artificial Intelligence</li> </ul>			3 3		3 3
	<b>M4: Basics of information systems</b> <ul style="list-style-type: none"> <li>▪ Information Systems 1</li> </ul>		6	6	6	6
Mathematics	<b>M5: Basics of mathematics</b> <ul style="list-style-type: none"> <li>▪ Statistical Signal Processing</li> <li>▪ Numerical and symbolical methods for Bioinformatics</li> </ul>	3 3		3 3	3	3 3
		18 ECTS	18 ECTS	18 ECTS	18 ECTS	18 ECTS

Figure 3: Leveling phase - Assignment of bridge modules and courses to bachelor or master grades in different fields.

**Module 1: *Basics of molecular biology (Bridge module)***

Courses:

4,5 ECTS: Molecular biology of the cell I (2 VO, 1 UE)

**Module 2: *Basics of biochemistry (Bridge module)***

Courses:

a) 3 ECTS: Introduction: instrumental analytics for Life-Sciences (2 KV)

b) 3 ECTS: Chemistry for Physicist II (2 VO)

c) 1,5 ECTS: Basics in Chemistry for Bioinformatics (1KV)

**Module 3: *Basics of algorithm and data structures (Bridge module)***

Courses:

a) 3 ECTS: Algorithms and Data Structures 2 (2 VO)

b) 3 ECTS: Artificial Intelligence (2 VO)

**Module 4: *Basics of information systems (Bridge module)***

Courses:

6 ECTS: Information Systems 1 (2 VO, 2 UE)

**Module 5: *Basics of mathematics (Bridge module)***

Courses:

a) 3 ECTS: Statistical Signal Processing (2 VO)

b) 3 ECTS Numerical and symbolical methods for Bioinformatics (2 KV)

**Module 6: *Bioinformatics I: Sequence analysis and phylogenetics (Compulsory module)***

Courses:

6 ECTS: Bioinformatics I: sequence analysis and phylogenetics (4 KV)

**Module 7: *Free elective courses***

12 ECTS: free selectable

**Module 8: *Bioinformatics II: Theoretical Bioinformatics and machine learning (Compulsory module)***

Courses:

a) 6 ECTS: Bioinformatics II: theoretical Bioinformatics and machine learning (4 VO)

b) 3 ECTS: Bioinformatics II: theoretical Bioinformatics and machine learning (2 UE)

**Module 9: *Bioinformatics III: Struktural Bioinformatics and gene analysis (Compulsory module)***

3 ECTS: Bioinformatics III: structural Bioinformatics and gene analysis (2 KV)

**Module 10: *Bioinformatics IV: Information systems (Compulsory module)***

6 ECTS: Bioinformatics IV: information systems for Bioinformatics (4 KV)

**Module 11: *Bioinformatics V: Mathematical methods of Bioinformatics (Compulsory module)***

a) 3 ECTS: Algebraic and discrete methods for Biology (2 KV)

b) 3 ECTS: Mathematical modelling and scientific computing in the biosciences I (2 VO)

c) 3 ECTS: Mathematical modelling and scientific computing in the biosciences II (2 VO)

**Module 12: *Seminar Bioinformatics (Compulsory module)***

3 ECTS: Seminar Bioinformatics (2 SE) or Seminar computational biology (2 SE)

**Module 13: *Project practical Bioinformatics (Compulsory module)***

9 ECTS: Project Bioinformatics (4 PR)

**Module 14: *Elective courses A: Computer science (elective module)***

6 ECTS from an arbitrary combination of:

- Introduction to R with applications to bioinformatics (3 ECTS 2 KV)
- Special Topics on Bioinformatics (3 ECTS 2 KV)
- Software Engineering (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Software Architectures (4,5 ECTS 3 KV)
- Computer Architecture 2 (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Security Models in Information Systems (3 ECTS 2 KV)
- Human-Computer Interaction (3 ECTS 2 VO)
- Web Information Retrieval (3 ECTS 2 KV)
- Applied Knowledge Processing (3 ECTS 2 VO)
- Digital Image Processing (3 ECTS 2 KV)
- Networks and Distributed Systems (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Compiler Construction (3 ECTS 2 VO, 3 ECTS 2 UE)
- Network Management (4,5 ECTS 3 KV)
- Testing Software Systems (3 ECTS 2 KV)
- IT Law and Computer Forensics (3 ECTS 2 VO)
- Requirements Engineering (3 ECTS 2 KV)

- Practical in Computer Science (7,5 ECTS 5 PR)
- Practical in Software Engineering (7,5 ECTS 5 PR)
- Biometric Identification (3 ECTS 2 VO)
- Theoretical Concepts of Machine Learning (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Parallel Computing (4,5 ECTS 3 KV)
- Computer Architecture 1 (4,5 ECTS 3 VO, 1,5 ECTS 1 UE)
- Embedded and Pervasive Systems (3 ECTS 2 VO, 1,5 ECTS 1 UE)

**Module 15: *Elective courses B: Biology/Chemistry/Physics/Mathematics (elective module)***

6 ECTS from an arbitrary combination of:

*Biology/Physics:*

- Biophysics I (4,5 ECTS 3 VO)
- Biophysics II (3 ECTS 2 VO)
- Biophysics III (3 ECTS 2 VO)
- Molecular biology of the cell II (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Biological signalling I (3 ECTS 2 VO)
- Biological signalling II (1,5 ECTS 1 VO)
- Characterization of Bio-Nanostructures (3 ECTS 2 VO)
- Microscopy on biomolecules (3 ECTS 2 VO)
- Bioanalytics I (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Genetics I (1,5 ECTS 1 VO)
- Genetics II (1,5 ECTS 1 VO)
- Genetics III (1,5 ECTS 1 VO)
- Genetics IV (1,5 ECTS 1 VO)
- Molecular biology I (3 ECTS 2 VO)
- Molecular biology I (3 ECTS 2 PR)
- Molecular biology II (1,5 ECTS 1 VO)
- Molecular biology II (4,5 ECTS 3 PR)
- Bioanalytics II (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Theoretical biophysics I (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Theoretical biophysics II (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Genomic Data Analysis (6 ECTS 4 VU)

*Chemistry:*

- Analytical Chemistry III (2,6 ECTS 2 VO)

- Biochemistry (2,6 ECTS 2 VO)
- Seminar on NMR-spectroscopy (3 ECTS 2 SE)
- Practical NMR-spectroscopy (3 ECTS 2 KV)
- Chemical Calculations (1,6 ECTS 1 KV)
- Biological Chemistry Seminar (3,2 ECTS 2 SE)
- Organic Chemistry 1 (5,2 ECTS 4 VO)
- Laboratory Course of Organic Chemistry I (8,4 ECTS 7 PR)
- Biomolecular NMR spectroscopy (2,6 ECTS 2 VO)

*Mathematics:*

- Integral equations and boundary value problems (3 ECTS 2 UE, 6 ECTS 4 VO)
- Partial differential equations (6 ECTS 4 VO, 3 ECTS 2 UE)
- Fuzzy logic (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Combinatorics (3 ECTS 2 VO Algorithmic combinatorics, 3 ECTS 2 VO Analytical combinatorics)
- Computer algebra (4,5 ECTS 3 KV Computer algebra, 3 ECTS 2KV Logic as a working language)
- Optimization (6 ECTS 4 KV)
- Combinatorial optimization (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Stochastic processes (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Functional analysis and integration theory (6 ECTS 4 VO, 3 ECTS 2 UE)
- Inverse problems (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Markov chains (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Stochastic simulation (3 ECTS 2 VO, 1,5 ECTS 1 UE)
- Special Topics on mathematical methods in Bioinformatics (3 ECTS 2 KV)
- Stochastic processes and modeling of time series (4 ECTS 2 KV)

**Module 16: *Ethics and Gender Studies (Compulsory module)***

- a) 3 ECTS: Ethics and Gender Studies (2 VO) or Gender Studies Managing Equality TN (2 KV)
- b) 3 ECTS: Ethical issues of Bioinformatics (2 SE)

**Module 17: *Master thesis (Compulsory module)***

- a) 3 ECTS: Master seminar (2 SE)
- b) 22 ECTS: Master thesis
- c) 2 ECTS: Master examination