Freie Universität Berlin

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OVERVIEW OF CONTENTS

Please note that this English version of the study and examination regulations is nothing more than an aid to orientation. Solely the German version is legally binding.

Study and Examination Regulations for the Master's Degree Program in Bioinformatics of the Departments of Biology, Chemistry and Pharmacy and Mathematics and Computer Science of Freie Universität Berlin and Charité – Universitätsmedizin Berlin

Preamble

Based on Sec. 14 (1), first sentence, No. 2 of the Partial Basic Rules and Regulations (Teilgrundordnung) (test model) of Freie Universität Berlin dated October 27, 1998 (Freie Universität Official Announcements No. 24/1998) and Sec. 9 (1) No. 1 of the Berlin University Medicine Act of December 5, 2005 (Law and Regulatory Gazette p. 739), last amended on February 2, 2018 (Law and Regulatory Gazette p. 160), in conjunction with Sec. 74 of the Act on Higher Education in the State of Berlin (Berlin Higher Education Act – BerlHG) in the version thereof dated July 26, 2011 (Law and Regulatory Gazette p. 378), last amended on February 2, 2018 (Law and Regulatory Gazette p. 160), the Bioinformatics Joint Commission appointed by the Department of Mathematics and Computer Science of Freie Universität Berlin and the Department of Biology, Chemistry and Pharmacy of Freie Universität Berlin and by Charité – Universitätsmedizin Berlin (Charité) issued the following study and examination regulations for the master's degree program in Bioinformatics of the Departments of Biology, Chemistry and Pharmacy and of Mathematics and Computer Science of Freie Universität Berlin and Charité – Universitätsmedizin Berlin on September 23, 2019:*

Table of Contents

Sec. 1 Scope

(1) These regulations stipulate the objectives, content and structure of the master's degree program in Bioinformatics of the Departments of Biology, Chemistry and Pharmacy and of Mathematics and Computer Science of Freie Universität Berlin and Charité – Universitätsmedizin Berlin (master’s degree program), and, by way of supplement to the framework study and examination regulations of Freie Universität Berlin (RSPO), the requirements and procedures for completion of studies and examinations (academic coursework) in the master’s degree program. The Bioinformatics Joint Commission appointed by the Department of Mathematics and Computer Science of Freie Universität Berlin and the Department of Biology, Chemistry and Pharmacy of Freie Universität Berlin and by Charité is responsible for the organization of teaching and studies.

(2) This program is a consecutive master's degree program in accordance with Sec. 23 (3) No. 1 a) BerlHG.

Sec. 2 Qualification objectives

(1) Graduates have mastered the essential aspects of modern bioinformatics as well as the relevant principles of mathematics, computer science and biomedical science. They are capable of independent analysis of specific problems in bioinformatics, comparison of different approach methodologies and assessment of the advantages and drawbacks of these methodologies.

* These regulations were confirmed by the Executive Board of Freie Universität Berlin on September 25, 2019, and by the Executive Board of Charité on October 8, 2019.

Graduates are capable of selecting a suitable approach to a problem from among different possibilities, working out a solution independently and arguing for their results within an interdisciplinary context. They are capable of independent research and development in the field of bioinformatics with an eye to specific profiles. Those who have studied the Complex Systems profile are able to analyze and simulate complex biological systems. Those who have studied the Data Science profile are able to analyze large data sets from the area of life sciences and can extract complex contexts from them. Those who have studied the Advanced Algorithms profile are able to develop and analyze complex algorithms and apply them to typical data from the field of bioinformatics.

(2) Alongside their subject-specific qualifications, graduates possess teamwork, communication and transference skills and are familiar with aspects relating to gender and diversity.

(3) Graduates have been prepared for subject-specific leadership roles in various fields of activity. These include, for example, the areas of pharmacy, medicine, and biotechnology and corresponding facilities and institutions in the industrial, research and administration sectors. A further academic qualification can also be acquired within the framework of a doctorate.

Sec. 3 Study content

(1) This master's degree program is a direct response to an ongoing paradigm shift in medicine and the biological sciences. In the future, further research in these fields will be based to an increasing degree on the analysis and interpretation of large amounts of biological data. The use of computers, in combination with precision mathematical models and efficient algorithms, will be indispensable for this work. With in-depth education in the corresponding branches of mathematics, computer science, biology and medicine, this program imparts the skills needed to recognize the relevant problems in biological science, develop appropriate mathematical or computer science solutions and correctly interpret the results within the biological context. The option to choose a profile area allows students to choose their own area of focus for their education.

(2) The students are familiarized with the content and methods of fields of study related to ongoing research. In addition to subject-specific skills in bioinformatics, they acquire interdisciplinary competence and key qualifications with a view to future research work or managerial functions.

Sec. 4 Academic and departmental advising

(1) General student advising is provided by the Center for Academic Advising and Psychological Counseling at Freie Universität Berlin.

(2) Departmental advice relating to the program and the subject is provided by the instructors who offer courses in the master's degree program during regular office hours. In addition, at least one student assistant is also available in an advisory capacity. It is also recommended that the suitability of the student's individual program plans should be discussed with the program coordinator.

Sec. 5 Examining board

The examining board established by the Bioinformatics Joint Commission for the master's degree program is responsible for organizing the examinations and for the other tasks mentioned in the RSPO.

Sec. 6 Standard study period

The standard study period is four semesters.

Sec. 7 Structure and outline; scope of performance

(1) The master’s degree program comprises 120 credits split between modules comprising 90 credits and the master’s thesis with accompanying colloquium, which comprises 30 credits. The study phase has three parts: the fundamental study portion, comprising 30 credits; the profile study portion, comprising 45 credits; and the supplementary study portion, comprising 15 credits. Students can choose from three different concentrations when selecting a profile area: (1.) Complex Systems, (2.) Data Science and (3.) Advanced Algorithms. Each student chooses his or her individual profile area by successfully completing all of the required modules for that profile area.

(2) Students are required to complete the following modules during the fundamental study portion of the program:

– Foundations in Computer Science (6 credits),
– Foundations in Mathematics and Statistics (6 credits),
– Foundations in Bio-Medicine (6 credits) and – Introduction to Focus Areas (12 credits).

(3) During the profile study portion of the program, students are required to choose and complete one of three specific concentrations.

1. Complex Systems
   a) Mandatory area comprising 30 credits: The following modules must be completed:
      – Module: Complex Systems in Bioinformatics (10 credits),

- Lecture module: Complex Systems in Biomedical Applications (5 credits),
- Module: Ethics and Policy Questions (5 credits) and
- Module: Research Internship (10 credits).

b) Elective area comprising 15 credits: Modules totaling 15 credits must be chosen and completed:

- Module: Current Research Topics in Complex Systems (5 credits),
- Lecture module: Advanced Network Analysis (5 credits),
- Lecture module: Human Evolution (5 credits),
- Lecture module: Special Aspects of Complex Systems (5 credits),
- Lecture module: Selected Topics in Complex Systems (10 credits),
- Practical module: Computer-Aided Drug Design (5 credits),
- Practical module: Current Topics in Cell Physiology (5 credits),
- Practical module: Computational Systems Biology (5 credits).

2. Data Science

a) Mandatory area comprising 30 credits: The following modules must be completed:

- Module: Data Science in the Life Sciences (15 credits),
- Module: Ethics and Policy Questions (5 credits) and
- Module: Research Internship (10 credits).

b) Elective area comprising 15 credits: Modules totaling 15 credits must be chosen and completed:

- Module: Medical Bioinformatics (10 credits),
- Module: Current Research Topics in Data Science in Life Sciences (5 credits),
- Lecture module: Advanced Network Analysis (5 credits),
- Lecture module: Machine Learning in Bioinformatics (5 credits),
- Lecture module: Big Data Analysis in Bioinformatics (5 credits),
- Lecture module: Complex Data Analysis in Physiology (5 credits),
- Lecture module: Methodology for Clinical Trials (5 credits),
- Lecture module: Advanced Biometrical Methods (5 credits),
- Lecture module: Special Aspects of Data Science in the Life Sciences (5 credits),
- Lecture module: Selected Topics in Data Science in the Life Sciences (10 credits),
- Practical module: Current Topics in Medical Genomics (5 credits),
- Practical module: Machine Learning in Bioinformatics (5 credits),
- Module: Special Aspects of Data Management (5 credits),
- Module: Distributed systems (5 credits),
- Module: Network-Based Information Systems (5 credits).

3. Advanced Algorithms

a) Mandatory area comprising 30 credits: The following modules must be completed:

- Module: Advanced Algorithms for Bioinformatics (10 credits),
- Lecture module: Methods in Life Sciences (5 credits),
- Module: Ethics and Policy Questions (5 credits) and
- – Module: Research Internship (10 credits).

b) Elective area comprising 15 credits: Modules totaling 15 credits must be chosen and completed:

- Module: Biodiversity and Evolution (10 credits),
- Module: Medical Bioinformatics (10 credits),
- Module: Structural Bioinformatics (10 credits),
- Module: Current Research Topics in Advanced Algorithms (5 credits),
- Lecture module: Selected Topics in Advanced Algorithms (10 credits),
- Lecture module: Special Aspects of Complex Systems (5 credits),
- Practical module: Applied Sequence Analysis (5 credits),
- Practical module: Environmental Metagenomics (5 credits),
- Practical module: Current Topics in Medical Genomics (5 credits),
- Practical module: Current Topics in Structural Bioinformatics (5 credits),
- Module: Higher Algorithmics (10 credits).

(4) In the supplementary area comprising 15 credits, students can choose from all modules from the mandatory and elective areas in the other two profile areas that were not chosen. Modules totaling 15 credits must be chosen and completed.

(5) At least one lecture module in total must be chosen and completed within the elective area of the chosen profile area and in the supplementary area.

(6) At least one practical module in total must be chosen and completed within the elective area of the chosen profile area and in the supplementary area.

(7) The module descriptions in Annex 1 provide information for the modules of the master's degree program regarding admission requirements, content and qualification objectives, forms of teaching and learning, time requirements, forms of active participation, examination work required alongside studies, obligations regarding regular participation in the forms of teaching and learning, the credits assigned to the relevant modules, the standard duration and the frequency with which the modules are offered. For the module titled "Data Science in the Life Sciences" (15 credits), please see the Study and Examination Regulations for the Joint Master's Degree Program in Data Science of the Departments of Mathematics and Computer Science and Education and Psychology of Freie Universität Berlin. For the modules titled "Special Aspects of Data Administration" (5 credits), "Distributed Systems" (5 credits), and "Network-Based Information Systems" (5 credits), please see the Study and Examination Regulations for the Master's Degree Program in Computer Science of the Department of Mathematics and Computer Science of Freie Universität Berlin. For the module titled "Higher Algorithmics" (10 credits), please see the Study and Examination Regulations for the Master's Degree Program in Computer Science of the Department of Mathematics and Computer Science of Freie Universität Berlin.

(8) The sample study plans in Annex 2 provide information on the recommended sequence of studies in the master's degree program.

Sec. 8 Forms of teaching and learning

(1) The following forms of teaching and learning are offered as part of the master's degree program:

1. In lectures (V), the content of each course is presented and explained by the instructor. The instructors impart teaching content accompanied by references to specialized literature and encourage students to work independently and think critically.
2. Exercises (Ü) typically take place in small groups to accompany a lecture. In the groups, the lecture content is repeated in outline, and students apply the material learned in practice based on assigned exercises.
3. Seminars (S) serve the purpose of exemplary familiarization with content, theories and methods of areas of specialization within bioinformatics based on clearly defined thematic areas. In the seminars, students formulate, present and discuss teaching content under the guidance of an instructor and based on specialized literature and empirical findings.
4. In practical seminars (PS), students work under supervision, alone or in small groups, on substantial practical or scientific problems. The focus of project work is on the process of finding a solution, meaning practical application of suitable techniques and processes using scientific findings and methods. Interdisciplinary qualifications such as teamwork, communication and transference skills are also acquired, and responsible and gender-sensitive conduct is practiced.
5. Seminar-style instruction (sU) is used to convey application-oriented knowledge of a specific delineated subject area; participants work on tasks independently, with the results being demonstrated by the students, followed by critical discussion as a group.

(2) The forms of teaching and learning pursuant to paragraph 1 can be used in blended learning arrangements. In these arrangements, on-campus studies are combined with electronic Internet-based media (e-learning). In this case, selected teaching and learning activities are offered via the central e-learning applications of Freie Universität Berlin and carried out by students individually or in groups, either on their own or with supervision. Blended learning can be used in the execution phase (exchange and discussion of learning objects, solving tasks, intensification of communication between learner and instructor), or in the follow-up phase (monitoring learning outcomes, transfer support).

Sec. 9 Master's thesis

(1) The goal of the master's thesis is to demonstrate that the student is able to work independently on an advanced task from the field of bioinformatics using scientific methods and to present and evaluate the results obtained in writing and orally in an appropriate manner.

(2) Students will be admitted to work on a master's thesis upon application if they

1. were most recently enrolled at Freie Universität Berlin within the master's degree program and
2. they have successfully completed modules totaling 60 credits or more within the master's degree program.

(3) The application for admission to the master's thesis must be accompanied by evidence of the prerequisites in accordance with paragraph 2, as well as confirmation from an instructor who is entitled to administer exams that he or she is willing and able to act as supervisor for the master's thesis. The examining board decides on the application. If no confirmation of intent to supervise the master's thesis as per the first sentence above is submitted, the examining board will appoint a supervisor accordingly. Students are given the opportunity to propose their own topics, but are not entitled to have these proposals accepted.

(4) The master's thesis should be approximately 70 pages in length.

(5) The examining board assigns the topic of the master's thesis in consultation with the supervisor. The topic and task must be designed in such a way as to ensure the work can be completed before the deadline. The assignment and submission of the master's thesis must be recorded and the information kept on file. When the thesis is submitted, the student must affirm in writing that he or she has written the paper independently, using only the sources and aids listed. The master's thesis is to be submitted typewritten as three bound copies and as a Portable Document Format (PDF) electronic version. The PDF file must contain the text in machine-readable format, not merely in graphic form; furthermore, there must be no rights restrictions. A copy of the master's thesis may be incorporated into the institute library with the student's permission after he or she completes the program.

(6) The assigned period for the thesis work is 23 weeks. The assigned period begins on the date on which the topic is assigned by the examining board. The topic can be returned once within the first four weeks and is then considered not to have been assigned. The examining board decides on the application in consultation with the supervisor of the master's thesis.

(7) The written portion must be written in English. In response to a well-founded application, the examining board may also permit the master's thesis to be written in German. If a student has been unable to work on the thesis for a period of more than eight weeks for a valid reason, the examining board will decide whether the master's thesis must be begun afresh. The examination with regard to the master's thesis is deemed not to have been taken if the examining board requires the thesis to be resubmitted.

(8) The master's thesis must be evaluated by two instructors entitled to administer examinations as assigned by the examining board. One of these two instructors should be the supervisor of the master's thesis. At least one of the two examiners must be involved in teaching in the master's degree program and simultaneously be an instructor at the Department of Mathematics and Computer Science of Freie Universität Berlin or the Department of Biology, Chemistry and Pharmacy at Freie Universität Berlin or at Charité.

(9) If approved by the examining board, the work on the master's thesis can also be done externally at a suitable business or scientific or research institution, as long as scientific and scholarly supervision by an examiner in the program in bioinformatics is ensured. In this case, the other examiner may come from the business or scientific or research institution.

(10) The student is deemed to have received a passing grade on the master's thesis if the grade awarded for the thesis is at least "sufficient" (4.0). The grade is calculated as the arithmetic mean of the two individual grades. If one of the examiners issues a grade of "insufficient" (5.0) or if the two individual grades from the examiners differ by 2.0 or more, then the examining board commissions a third examiner to evaluate the master's thesis. In this case, the grade for the master's thesis is calculated as the arithmetic mean of the grades awarded by all three examiners.

(11) The master's thesis is accompanied by a colloquium, which generally takes place within the assigned working group. Students are expected to give a one-time presentation lasting approximately 30 minutes on the progress of their master's thesis.

(12) Students are permitted to have coursework counted toward the master's thesis; an application must be submitted to the examining board for this purpose. It is a prerequisite for coursework to be counted toward the thesis in this way that the examination conditions and the assignment for the coursework being submitted must not differ substantially in terms of quality, level, learning outcomes, scope, and/or profile from the examination conditions and the assignment involved in a master's thesis that is to be prepared within the master's degree program and shapes the qualification profile for the master's degree program in a particular manner.

Sec. 10 Master's thesis, special procedure

(1) Students who have passed the qualifying examination for Phase II of the International Max Planck Research School for Biology and Computation (IMPRSBAC) may submit an application to the examining board for permission to write a master's thesis under the special procedure, enclosing the relevant documents.

(2) The prerequisite for permission to write a master's thesis under the special procedure is coursework in accordance with Sec. 9 (2) or equivalent, which has been graded "good" (2.0) or better in accordance with Sec. 18 (1) of the framework study and examination regulations of Freie Universität Berlin (RSPO). Additionally, a well-founded written statement from a university instructor stating that he or she is willing and able to supervise the future dissertation project is required. Otherwise, admission to the doctoral procedure is subject to the relevant doctoral regulations.

(3) In the event of permission to write a master's thesis under the special procedure, the thesis is written independently using current scientific methods, taking the form of a scientifically grounded approach with presentation and subsequent discussion. The approach described in the first sentence above must describe the dissertation topic and situate it within the current status of research in the field.

(4) The provisions of Sec. 9 (6), first sentence, apply to the time spent working on the master's thesis under the

special procedure. The master's thesis under the special procedure must be written in English.

(5) When the thesis is submitted, the student must affirm in writing that he or she has written the master's thesis under the special procedure independently, using only the sources and aids listed. The master's thesis under the special procedure is to be submitted typewritten as three bound copies and as a Portable Document Format (PDF) electronic version. The PDF file must contain the text in machine-readable format, not merely in graphic form; furthermore, there must be no rights restrictions.

(6) The master's thesis under the special procedure must be evaluated after submission by the appointed supervisor and by an additional examiner appointed by the examining board. At least one of the two examiners must be involved in teaching in the master's degree program and simultaneously be an instructor at the Department of Mathematics and Computer Science at Freie Universität Berlin, or at the Department of Biology, Chemistry and Pharmacy at Freie Universität Berlin, or at Charité – Universitätsmedizin Berlin. The evaluations must be submitted to the examining board four weeks after the thesis is submitted.

(7) The master's thesis under the special procedure is accompanied by a colloquium, which generally takes place within the assigned working group. Students are expected to give a one-time presentation lasting approximately 30 minutes on the progress of their master's thesis.

(8) The student is deemed to have received a passing grade on the master's thesis under the special procedure if the grade awarded for this thesis is at least "sufficient" (4.0). The grade is calculated as the arithmetic mean of the two individual grades. If one of the examiners issues a grade of "insufficient" (5.0) on the master's thesis under the special procedure or if the two individual grades from the examiners differ by 2.0 or more, then the examining board commissions a third examiner to evaluate the master's thesis. In this case, the grade for the master's thesis is calculated as the arithmetic mean of the grades awarded by all three examiners.

(9) Students are permitted to have coursework counted toward the master's thesis under the special procedure; an application must be submitted to the examining board for this purpose. It is a prerequisite for coursework to be counted toward the thesis in this way that the examination conditions and the assignment for the coursework being submitted must not differ substantially in terms of quality, level, learning outcomes, scope, and/or profile from the examination conditions and the assignment involved in a master's thesis under the special procedure that is to be prepared within the master's degree program and shapes the qualification profile for the master's degree program in a particular manner.

Sec. 11 Electronic examinations

(1) Electronic examinations are administered and evaluated using digital technologies.

(2) Before an examination where digital technologies are used, the suitability of these technologies with regard to the intended examination tasks and the administration of the electronic examination must be verified by two examiners.

(3) The authenticity of the author and the integrity of examination results must be safeguarded. To this end, unique identifiers are assigned to the examination results in the form of electronic data, and these are associated uniquely and permanently with the student. It must be ensured that electronic data remain unchanged and complete for purposes of assessment and later verification.

(4) An automatically generated assessment of examination performance must be checked by an examiner if requested by the student in question.

Sec. 12 Multiple choice test

(1) Multiple choice test questions must be administered by two examiners.

(2) If, during assessment of student performance on multiple choice tests, it becomes apparent that there is a noticeable pattern of errors in answering individual questions, both examiners are required to review the tasks again to ensure that they make it possible to capture valid information on the qualification goals of the module in question, along with reliable exam results. If the review establishes that individual examination tasks are flawed, these tasks are left outside consideration when determining the results. The number of examination tasks to be taken into account when determining the examination result is reduced accordingly. Reducing the number of examination tasks must not be to a student's detriment. If the examination tasks to be eliminated account for more than 15% of the total multiple choice evaluation points achievable, one of the examiners is required to forward the full exam documentation to the examining board without delay and before the examination results are announced. The examining board then decides whether the entire exam must be repeated or can be evaluated according to the standards set forth above, leaving the flawed tasks outside consideration.

(3) An examination in the form of a multiple choice test is deemed to have been passed if the student has achieved at least 50% of the achievable total of points (absolute pass limit) or if the number of points achieved by the student is not more than 10% lower than what participants in the examination have achieved on average (relative pass limit). If the relative pass limit applies, the

student is still required to have achieved at least 40% of the achievable evaluation points in order to be considered to have passed the exam.

(4) Examinations taken in multiple choice form are graded as follows: If the student has achieved the minimum point score required to pass the examination pursuant to paragraph 3 above, then the grade is

– very good, if he or she achieves at least 75%,
– good, if he or she achieves at least 50 but less than 75%,
– satisfactory, if he or she achieves at least 25 but less than 50%, and
– sufficient, if he or she achieves zero or less than 25% of the points achievable beyond the minimum point scores required pursuant to paragraph 3 above; in all other respects, the RSPO applies to the grades used.

(5) The evaluation specifications pursuant to paragraphs 3 and 4 above do not apply if

1. the instructors entitled to administer exams who assigned the examination tasks pursuant to paragraph 1 above are identical to those who evaluate the student's performance on the multiple choice test, or
2. the achievable points on the examination tasks in multiple choice form do not exceed 25% of a written exam that is administered only partly in multiple choice form.

Sec. 13 Repetition of examinations

(1) If the student does not pass, the master's thesis can be repeated one time and other examinations that accompany the student's study program can be repeated three times.

(2) Examinations passed with a grade of "sufficient" (4.0) or better cannot be repeated.

Sec. 14 Study abroad

(1) It is recommended that students spend time abroad. Within the scope of study abroad, students are urged to complete coursework that can be applied toward this master's degree program.

(2) Study abroad must be preceded by conclusion of an agreement between the student, the chair of the examining board and the appropriate body at the relevant foreign academic institution regarding the duration of study abroad, the academic work expected during study abroad, which must be equivalent to the academic work undertaken in the master's degree program, and the credits awarded for this academic work. Academic work completed as per the agreement is then credited accordingly.

(3) The second or third subject-specific semester within the master's degree program is recommended as a suitable time for study abroad.

Sec. 15 Completion of studies

(1) To complete the program, students must have completed the academic work required pursuant to Sec. 7 in conjunction with Sec. 9 and 10 hereof.

(2) The degree will not be awarded if the student has failed to complete academic work on a final basis or failed exams without the option to retake or is currently involved in a pending examination procedure at any higher education institution in the same study program or in a module that is identical or comparable to one of the modules that must be completed within the master's degree program and must be taken into account in determining the overall grade.

(3) The application for determining the awarding of the degree must be accompanied by evidence that the prerequisites as detailed in paragraph 1 above are met and by an affirmation that none of the cases enumerated in paragraph 2 above applies to the applicant. The relevant examining board decides on the application.

(4) On the basis of the passed examination, the university degree of Master of Science (M.Sc.) is awarded. The student will receive a grade report and degree certificate (Annexes 3 and 4), as well as a diploma supplement (English and German versions). Furthermore, a supplement to the grade report detailing individual modules and their components (transcript) will also be issued. English versions of the grade report and degree certificate are also issued upon request.

Sec. 16 Entry into force and transitional provisions

(1) These regulations enter into force on the day after publication hereof in the Official Announcements (Official Register of Freie Universität Berlin) and in the Official Notices of Charité – Universitätsmedizin Berlin.

(2) At the same time, the study regulations for the master's degree program of June 6, 2012 (Freie Universität Official Announcements 77/2012, p. 1494), and the examination regulations for the master's degree program of June 6, 2012 (Freie Universität Official Announcements 77/2012, p. 1520), cease to apply.

(3) These regulations apply to students who enroll in the master's degree program at Freie Universität Berlin following their entry into force. Students who enrolled in the master's degree program at Freie Universität Berlin before these regulations entered into force are required to study and complete their coursework based on the study

and examination regulations as per paragraph 2 above unless they apply to the examining board to continue the program and complete their coursework based on these regulations instead. When the student is re-registered in response to the application, the examining board is required to decide to what extent modules that have already been started or completed at the time of the application are taken into account or counted toward the coursework required pursuant to these regulations, upholding the requirements of protection of legitimate expectations and of equal treatment in the process. The decision regarding the re-registration application takes effect at the start of the period when courses are in session in the semester following the time when the application is submitted. The re-registration cannot be revised.

(4) The possibility of completing the study program on the basis of the study and examination regulations pursuant to paragraph 2 above must be offered until the end of the 2021 summer semester.

Annex 1: Module descriptions

Explanations:

Except where reference is made to other regulations, the module descriptions that follow designate the following for each module of the master's degree program:

- the module name,
- the person responsible for the module,
- the requirements for admission to the specific module,
- the content and qualification objectives of the module,
- the teaching and learning forms involved in the module,
- the estimated student workload needed to successfully complete a module,
- forms of active participation,
- the exam forms,
- the obligation to participate regularly,
- the credits assigned to the modules,
- the standard duration of the module,
- the frequency with which the module is offered, and
- the applicability of the module.

The information on the amount of time involved in the student workload takes the following into account in particular:

- active participation in on-campus studies,
- the time required for completion of minor tasks related to on-campus study,
- the time required for independent preparation and follow-up,
- the processing of study units in online study phases, l the time directly required to prepare for examinations, and
- the examination time itself.

The information on time requirements for self-study (including preparation and follow-up, examination preparation, etc.) is provided for guidance purposes to help students organize the time required for their module-related work. The information on the workload involved corresponds to the number of credits assigned to each module as the unit of measure for student workload as an approximation of the work required to successfully complete the module. One credit is equivalent to 30 hours. Where an obligation of regular participation is stipulated for the individual teaching and learning forms in question, this obligation, alongside active participation in the teaching and learning forms and successful completion of the examinations for a module, is a prerequisite for earning the credits assigned to the respective module. Participation is deemed to be regular if the student has attended at least 85% of the on-campus study time scheduled in the teaching and learning forms for a module. Even if there is no obligation of regular participation in a particular teaching and learning form for a module, it is strongly recommended nonetheless. The relevant instructor cannot establish attendance obligations for teaching and learning forms for which the text that follows merely recommends participation.

The relevant module exam – where stipulated – must be taken for each module. Graded modules are completed with only one examination (module exam). The module exam must reflect the qualification objectives of the module. It tests whether the objectives of the module have been reached based on an exemplary sampling. The scope of the examination is limited to what is required to achieve this. In modules for which alternative examination forms are stipulated, the examination form for each semester must be determined by the instructor responsible no later than at the first course meeting.

Active and – where stipulated – regular participation in the teaching and learning forms as well as successful completion of the examination requirements for a module are the prerequisites for earning the credits assigned to that module. In modules with no module examination, active participation and regular participation in the teaching and learning forms are the prerequisites for earning the credits assigned to that module.

1. Fundamental study portion

<table>
<tr><td colspan="4">Module: Foundations in Computer Science</td></tr>
<tr><td colspan="4">Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Computer Science</td></tr>
<tr><td colspan="4">Persons responsible for module: Module instructors</td></tr>
<tr><td colspan="4">Admission requirements: None</td></tr>
<tr><td colspan="4">Qualification objectives:
Students have acquired a fundamental understanding of mathematical concepts and methods in advanced algorithmics against the background of current research trends in bioinformatics. They have been familiarized with advanced tools for development and analysis of deterministic and randomized algorithms. They are familiar with concepts and methods of compressing data and making them accessible according to their entropy. They are familiar with concepts involved in parallel and vectorized algorithms and with paradigms for distributed computing. They can identify the concepts independently and apply the analytical methods to related problems themselves.</td></tr>
<tr><td colspan="4">Content:
Topics from the following areas are considered:
– Introduction to various types of algorithms and methods of analysis
– Fundamentals of compact data structures
– Graph theory and advanced graph algorithms
– Analysis of randomized data structures and algorithms
– Fundamentals and models involved in parallel and vectorized computing
– Concepts, paradigms, and frameworks for distributed computing</td></tr>
<tr><td>Forms of teaching and learning</td><td>On-campus studies
(weekly credit hours = SWS)</td><td>Forms of active participation</td><td>Workload
(hours)</td></tr>
<tr><td>Lecture</td><td>2</td><td>Follow-up on VL content and independently developing supplementary literature</td><td rowspan="2">On-campus time, V 30
Preparation and follow-up, V 60
On-campus time, Ü 30
Preparation and follow-up, Ü 40
Examination preparation and Examination 20</td></tr>
<tr><td>Exercise</td><td>2</td><td>Work on assigned exercises</td></tr>
<tr><td colspan="2">Module exam:</td><td colspan="2">Written exam (90 minutes); the written exam can also be taken electronically
or
as an oral exam (approx. 20 minutes)</td></tr>
<tr><td colspan="2">Module language:</td><td colspan="2">English</td></tr>
<tr><td colspan="2">Mandatory regular participation:</td><td colspan="2">Lecture: Participation recommended, exercise: Yes</td></tr>
<tr><td colspan="2">Total working time requirement:</td><td>180 hours</td><td>6 credits</td></tr>
<tr><td colspan="2">Duration of module:</td><td colspan="2">One semester</td></tr>
<tr><td colspan="2">Frequency of offering:</td><td colspan="2">Each winter semester</td></tr>
<tr><td colspan="2">Applicability:</td><td colspan="2">Master's degree program in Bioinformatics</td></tr>
</table>

Module: Foundations in Mathematics and Statistics

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students have acquired a fundamental understanding of advanced mathematical concepts and methods in the field of statistics, numerical analysis and optimization against the background of current research trends in bioinformatics and system biology. They are able to select problem-specific methods, apply them in practice and assess the quality of the results.

Content:

Topics from the following areas are considered:

- Linear programming (simplex algorithm, duality)
- Integer linear programming (branch and bound, cutting planes, branch and cut)
- Local search and metaheuristics
- Standard differential equations (modeling, analysis, sensitivity)
- Linear models and test theory
- Classification
- Bootstrap and model evaluation
- Markov models (EM, HMM, MCMC)

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 60 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	40 20
Module exam:		Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)		
Module language:		English		
Mandatory regular participation:		Lecture: Participation recommended, exercise: Yes		
Total working time requirement:		180 hours	6 credits	
Duration of module:		One semester		
Frequency of offering:		Each winter semester		
Applicability:		Master's degree program in Bioinformatics		

Module: Foundations in Bio-Medicine

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students have a fundamental understanding of fundamental concepts in the area of analysis of genomic data and how they relate to sickness and health. This also includes an understanding of which methods are suitable for searching for variants and interpretation in which cases and what the functional impact of these methods may be. Students learn to apply these findings independently in similar situations.

Content:

Topics from the following areas are considered:

- Mechanisms of action in mutations in the case of different modes of inheritance, e.g., monogenic, mitochondrial, or polygenic
- Lab methods of determining genetic variations (SNVs, SNPs, CNVs)
- Methods for interpretation and functional evaluation of mutations
- Cell organelles and their mutation-related malfunctioning with associated diseases and conditions – selected examples
- Gene regulation, e.g., long-range gene regulation, chromatin epigenetics and their significance to gene regulation
- Errors in gene regulation associated with diseases and conditions – selected examples
- Methods of collecting data in lab environments
- Handling of medical data

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V	30 60
Exercise	2	Work on assigned exercises	On-campus time, Ü Preparation and follow-up, Ü Examination preparation and Examination	30 40 20

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Lecture: Participation recommended, exercise: Yes	
Total working time requirement:	180 hours	6 credits
Duration of module:	One semester	
Frequency of offering:	Each winter semester	
Applicability:	Master's degree program in Bioinformatics	

Module: Introduction to Focus Areas

Higher education institution/department/teaching unit:
Freie Universität Berlin/Mathematics and Computer Science/Mathematics and Computer Science,
Freie Universität Berlin/Biology, Chemistry and Pharmacy/Biology, Chemistry and Biochemistry as well as
Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:
The students are familiar with sample issues and potential approaches to arriving at solutions from the three focus areas in relation to specific topics and are able to apply these issues and approaches in a manner geared toward problem solving. They recognize where which skills and abilities are needed and are able to analyze a problem specific to a certain area. Students can develop and compare differences and commonalities involved in working across the three different focus areas. They can find suitable literature on specific topics and are able to work on practical problems from the relevant areas.

Content:
This module presents sample issues and potential approaches to arriving at solutions from the three focus areas – Data Science for Bioinformatics, Complex Systems in Bioinformatics, and Advanced Algorithms in Bioinformatics – with an eye to specific topics and on an interdisciplinary basis. In the area of project work, teams of students work together on specific tasks on selected topics from these focus areas. They develop and implement specific proposals for solutions to problems geared toward real-world practice and present the results.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)
Lecture series	2	Specialized discussion, answering discussion questions, discussion of application problems, project work	On-campus time, RV 30 Preparation and follow-up, RV 30 On-campus time, SU 30 Project work, SU 270
Instruction in seminars	2		

Module exam:	Developing and presenting the results of project work, either as a written paper (report, approx. 5 pages) or as a scientific poster together with an oral presentation (approx. 5 minutes). – This module exam is not evaluated on a differentiated basis –	
Module language:	English	
Mandatory regular participation:	Yes	
Total working time requirement:	360 hours	12 credits
Duration of module:	One semester	
Frequency of offering:	Each winter semester	
Applicability:	Master's degree program in Bioinformatics	

2a. Profile study portion with a concentration in Complex Systems

Module: Complex Systems in Bioinformatics

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students have acquired a deeper understanding of fundamental mathematical and algorithmic concepts in the field of modeling, simulation and analysis of complex biological systems against the background of current research trends in system biology and biotechnology. They are capable of analyzing a given biological or medical problem, selecting a suitable modeling approach, independently developing a solution and assessing and communicating the results.

Content:

Topics from the following areas are considered in depth:

– Network structure analysis
– Graphical modeling
– Modeling of biochemical networks using standard differential equations
– Discrete modeling of regulatory networks
– Constraint-based modeling
– Stochastic and hybrid modeling

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü Preparation and follow-up, Ü On-campus time, S Preparation and follow-up, S Examination preparation and Examination	30 70 30 30 30 80 30
Exercise	2	Work on assigned exercises		
Seminar	2	Seminar presentation		
Module exam:		Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)		
Module language:		English		
Mandatory regular participation:		Lecture: Participation recommended, exercise and seminar: Yes		
Total working time requirement:		300 hours	10 credits	
Duration of module:		One semester		
Frequency of offering:		Each winter semester		
Applicability:		Master's degree program in Bioinformatics		

Lecture module: Complex Systems in Biomedical Applications

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students become familiar with complex systems in biology/physiology. They are able to evaluate and interpret from a critical perspective the collection, processing and preparation of the data used as a basis for modeling selected key processes.

Content:

Based on selected current examples from biology and physiology, the work steps involved in acquiring, processing, preparing and evaluating data up to the point of modeling of complex physiological contexts are developed in theory and practice. Models from the following areas are considered in depth:

– Fundamental biophysical and biochemical processes (e.g., free and facilitated diffusion through channel and transport proteins, active ion transport through membrane transporters, receptor-ligand interaction, interaction between structural and motor proteins)
– Structural and functional analysis of transport proteins
– Biological networks (e.g., signaling networks, metabolic networks, transporter models)
– Modeling of physiological functions of an organism (e.g., transportation of substances to the kidneys, muscle movement, temperature regulation, circadian rhythm)

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 30 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	30 30
Module exam:		Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)		
Module language:		English		
Mandatory regular participation:		Lecture: Participation recommended, exercise: Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Each summer semester		
Applicability:		Master's degree program in Bioinformatics		

Module: Ethics and Policy Questions

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Computer Science and Mathematics and Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students are familiar with the fundamental value systems and systems of standards involved in ethical and legal bases and the overall conditions that apply in the area of the life sciences, with a focus on medical research. They are able to use their existing knowledge for expertise that is bound by ethical and legal principles in typical fields of action, such as medicine, and recognize ethical issues and dilemmas. They are able to analyze ethical and legal issues relating to professional practice on a targeted basis based on suitable methods and sources and to bring about a reasonable and well founded solution. They reflect on their own core moral and ethical stance and how it affects their personal attitudes and actions. They are familiar with how ethics committees work and their tasks, especially in the field of medicine.

Content:

– Explanation and discussion of fundamental concepts such as standards, values, morals, and ethics from an interdisciplinary and a disciplinary perspective
– Social consequences of one's own actions
– Algorithmic bias ("discriminatory algorithms")
– Fundamentals of ethical discourse
– History of ethics committees in Germany
– Tasks and rules of ethics committees; how ethics committees work
– Current challenges
– Future prospects for ethical actions and research

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Practical seminar	2	Work on assigned tasks, presentation of results	On-campus time Preparation and follow-up	30 120

Module exam:	None	
Module language:	English	
Mandatory regular participation:	Yes	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Each winter semester	
Applicability:	Master's degree program in Bioinformatics	

Module: Research Internship				
Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics and Computer Science, Freie Universität Berlin/Biology, Chemistry and Pharmacy/Biology, Chemistry and Biochemistry as well as Charité – Universitätsmedizin Berlin				
Persons responsible for module: Module instructors				
Admission requirements: None				
Qualification objectives: The students have gained practical research experience in the area of data science and can apply instructional content learned in their study program to research practice. They have experience in project coordination and implementation and have teamwork skills.				
Content: Current research topics in bioinformatics.				
Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Internship	270 hours	Internship report and final presentation, supervision discussion	On-campus time Preparation and follow-up	270 30
Module exam:		None		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		300 hours	10 credits	
Duration of module:		One semester		
Frequency of offering:		Each semester		
Applicability:		Master's degree program in Bioinformatics		

Module: Current Research Topics in Complex Systems

Higher education institution/department/teaching unit:

Freie Universität Berlin/Mathematics and Computer Science/Mathematics and Computer Science,

Freie Universität Berlin/Biology, Chemistry and Pharmacy/Biology, Chemistry and Biochemistry as well as

Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students are familiar with current approaches in various subject fields in bioinformatics in the area of complex systems and are able to apply the key algorithms and analyze and interpret the results obtained.

Content:

This seminar uses current publications from prestigious specialized journals or subject-specific conferences to present the latest research work from the field of bioinformatics in the area of complex systems.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Seminar	2	Research, presentation and discussion	On-campus time Preparation and follow-up Examination preparation and Examination	30 70 50
Module exam:		Presentation with discussion (approx. 30 to 45 minutes) or written summation (approx. 10 pages)		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

Lecture module: Advanced Network Analysis

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students have advanced knowledge and skills relating to the modeling and analysis of biochemical, biophysical or biological properties of molecular networks, particularly with an eye to linking together experimental results, mathematical model and algorithmic implementation. They are able to design models for molecular networks and evaluate these from a critical perspective; they become familiar with algorithmic methods of analyzing these kinds of models and can gauge how meaningful they are and gain their own application experience.

Content:

Selected advanced content from the following areas is considered:

Network structure analysis

Dynamic modeling of molecular networks

Simulation, analysis and control of dynamic models

Network inference

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 30 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	30 30

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Participation recommended	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Human Evolution

Higher education institution/department/teaching unit: Freie Universität Berlin/Biology, Chemistry, Pharmacy/Biology

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students are familiar with current developments in the field of human evolution, especially at the molecular level. They are able to select and apply suitable algorithms to analyze existing data.

Content:

Topics relating to molecular evolution in humans are considered. Particular areas of focus include the following:

– Comparison of humans and other primates at the level of the genome, transcriptome, phenotype, cognitive abilities
– Archaic humans, the Neolithic Revolution, modern humans, adaptation, evolutionary medicine

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	1	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, S	15 15 30
Seminar	2	Discussion and presentation	Preparation and follow-up, S On-campus time, PS Preparation and follow-up, PS	30 30 10
Practical seminar	2	Work on assigned tasks, Presentation of results	Examination preparation and Examination	20

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Lecture: Participation recommended, seminar and practical seminar: Yes	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Special Aspects of Complex Systems			
Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics			
Persons responsible for module: Module instructors			
Admission requirements: None			
Qualification objectives: Students can apply the main terminology and results of a selected field in complex systems.			
Content: This module provides insight into a selected field of complex systems, for example programming methods for large data volumes from the area of biomedicine. In addition, it also covers research questions and application areas.			
Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)
Lecture	2	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V 30 Preparation and follow-up, V 30 On-campus time, Ü 30 Preparation and follow-up, Ü 30 Examination preparation and Examination 30
Exercise	2	Work on assigned exercises	
Module exam:		Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:		English	
Mandatory regular participation:		Participation recommended	
Total working time requirement:		150 hours	5 credits
Duration of module:		One semester	
Frequency of offering:		Irregular	
Applicability:		Master's degree program in Bioinformatics	

<table>
<tr><td colspan="4">Lecture module: Selected Topics in Complex Systems</td></tr>
<tr><td colspan="4">Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics</td></tr>
<tr><td colspan="4">Persons responsible for module: Module instructors</td></tr>
<tr><td colspan="4">Admission requirements: None</td></tr>
<tr><td colspan="4">Qualification objectives:
Students know the fundamentals in a special area or an application area of complex systems. They are able to apply what they have learned proficiently.</td></tr>
<tr><td colspan="4">Content:
Rotating content, for example advanced aspects of analysis of multimodal, distributed data, modeling, simulation, optimization of cell systems or machine learning.</td></tr>
<tr><td>Forms of teaching and learning</td><td>On-campus studies
(weekly credit hours = SWS)</td><td>Forms of active participation</td><td>Workload
(hours)</td></tr>
<tr><td>Lecture</td><td>4</td><td>Follow-up on VL content and independently developing supplementary literature</td><td rowspan="2">On-campus time, V 60
Preparation and follow-up, V 80
On-campus time, Ü 30
Preparation and follow-up, Ü 80
Examination preparation and Examination 50</td></tr>
<tr><td>Exercise</td><td>2</td><td>Work on assigned exercises</td></tr>
<tr><td colspan="2">Module exam:</td><td colspan="2">Written exam (90 minutes); the written exam can also be taken electronically
or
as an oral exam (approx. 20 minutes)</td></tr>
<tr><td colspan="2">Module language:</td><td colspan="2">English</td></tr>
<tr><td colspan="2">Mandatory regular participation:</td><td colspan="2">Participation recommended</td></tr>
<tr><td colspan="2">Total working time requirement:</td><td>300 hours</td><td>10 credits</td></tr>
<tr><td colspan="2">Duration of module:</td><td colspan="2">One semester</td></tr>
<tr><td colspan="2">Frequency of offering:</td><td colspan="2">Irregular</td></tr>
<tr><td colspan="2">Applicability:</td><td colspan="2">Master's degree program in Bioinformatics</td></tr>
</table>

Practical module: Computer-Aided Drug Design

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students know and understand various methods in chemical informatics and structural bioinformatics for computer-aided drug design, including available software and data sources. They can apply these methods in practice (programming portion) and can discuss and analyze them in critical terms based on a case study. The goal of this course is to enable students to design their own drug design pipeline and assess their results.

Content:

Topics from the following areas are considered in depth:

- Computer-assisted drug design
- Protein structures and protein-ligand interactions
- Available databases for protein and molecule structures, data generation and analysis
- Visualization of molecules and interactions
- Ligand-based methods (focus on small molecules):
  - Molecule descriptors, molecule comparison, substructures and filters
  - Virtual screening, machine learning
  - ADMET prediction
- Structure-based methods (focus on protein structures):
  - Homology modeling
  - Protein-ligand docking
  - Active centers in the protein and comparisons thereof
  - Off-target prediction
- Practical application, including programming (in Python)

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Practical seminar	4	Work on assigned tasks, presentation of results	On-campus time Preparation and follow-up Examination preparation and Examination	60 70 20
Module exam:		Written presentation (approx. 5 pages) or oral presentation (approx. 15 minutes)		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

Practical module: Current Topics in Cell Physiology

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students are familiar with different electrophysiological, molecular biological and optical measuring methods and can apply them to solve a physiological problem drawn from current research. They are capable of evaluating the results and comparing and assessing them using computer models they develop. Students are capable of weighing the advantages and limitations of different methods against one another and arriving at a critical assessment of the transferability of the computer models used to cellular systems.

Content:

Starting with a cytophysiological problem, experimental approaches to solving it are developed, including through the use of computer models. The following techniques may be used in the experimental segment:

– Impedance spectroscopy
– Polymerase chain reaction (PCR)
– Sequencing
– Transformation
– Transfection
– Western blot
– Confocal laser scanning microscopy

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Practical seminar	4	Work on assigned tasks, presentation of results	On-campus time Preparation and follow-up Examination preparation and Examination	60 70 20

Module exam:	Written presentation (approx. 5 pages) or oral presentation (approx. 15 minutes)	
Module language:	English	
Mandatory regular participation:	Yes	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Practical module: Computational Systems Biology

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students have practical experience in modeling and analysis of molecular networks. They are familiar with different methods and software tools for network analysis and can apply them to concrete problems in system biology and interpret the results and communicate them in an interdisciplinary context.

Content:

Topics from the following areas are considered in depth:

– Simulation of biochemical reaction networks
– Structure and dynamics of regulatory networks
– Metabolic engineering

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Practical seminar	4	Work on assigned tasks, presentation of results	On-campus time Preparation and follow-up Examination preparation and Examination	60 70 20
Module exam:		Written presentation (approx. 5 pages) or oral presentation (approx. 15 minutes)		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

2b. Profile study portion with a concentration in Data Science

<table>
<tr><td colspan="4">Module: Medical Bioinformatics</td></tr>
<tr><td colspan="4">Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin</td></tr>
<tr><td colspan="4">Persons responsible for module: Module instructors</td></tr>
<tr><td colspan="4">Admission requirements: None</td></tr>
<tr><td colspan="4">Qualification objectives:
Students have acquired a deeper understanding of basic concepts in the field of medical bioinformatics and genomics against the background of current research trends in bioinformatics and biotechnology. They grasp the various problems and objectives of biomedical genome analysis. They know which results can be derived from which clinical data and are capable of appropriately assessing computer-based predictions in the clinical and scientific context.</td></tr>
<tr><td colspan="4">Content:
Topics from the following areas are considered in depth:
– Coupling imbalance (LD), coupling analysis, association analyses
– Ontologies, semantic analysis, integrative analysis of biomedical data
– Analysis of medically relevant high-throughput sequencing data
– Exome and genome sequencing, interpretation and assessment of sequence variants. Analysis of RNA expression data and epigenomic data in a biomedical context</td></tr>
<tr><td>Forms of teaching and learning</td><td>On-campus studies
(weekly credit hours = SWS)</td><td>Forms of active participation</td><td>Workload
(hours)</td></tr>
<tr><td>Lecture</td><td>2</td><td>Follow-up on VL content and independently developing supplementary literature</td><td rowspan="4">On-campus time, V 30
Preparation and follow-up, V 45
On-campus time, Ü 15
Preparation and follow-up, Ü 60
On-campus time, S 30
Preparation and follow-up, S 60
Examination preparation and Examination 60</td></tr>
<tr><td>Exercise</td><td>1</td><td>Work on assigned exercises</td></tr>
<tr><td>Seminar</td><td>2</td><td>Research, presentation and discussion</td></tr>
<tr><td colspan="2">Module exam:</td><td colspan="2">Written exam (90 minutes); the written exam can also be taken electronically
or
as an oral exam (approx. 20 minutes)</td></tr>
<tr><td colspan="2">Module language:</td><td colspan="2">English</td></tr>
<tr><td colspan="2">Mandatory regular participation:</td><td colspan="2">Lecture: Participation recommended, exercise and seminar: Yes</td></tr>
<tr><td colspan="2">Total working time requirement:</td><td>300 hours</td><td>10 credits</td></tr>
<tr><td colspan="2">Duration of module:</td><td colspan="2">One semester</td></tr>
<tr><td colspan="2">Frequency of offering:</td><td colspan="2">Irregular</td></tr>
<tr><td colspan="2">Applicability:</td><td colspan="2">Master's degree program in Bioinformatics</td></tr>
</table>

Module: Current Research Topics in Data Science in Life Sciences

Higher education institution/department/teaching unit:

Freie Universität Berlin/Mathematics and Computer Science/Mathematics and Computer Science, and

Freie Universität Berlin/Biology, Chemistry and Pharmacy/Biology, Chemistry and Biochemistry as well as

Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students are familiar with current approaches in various subject fields in bioinformatics in the area of data science and are able to apply the key algorithms and analyze and interpret the results obtained.

Content:

This seminar uses current publications from prestigious specialized journals or subject-specific conferences to present the latest research work from the field of bioinformatics in the area of data science.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Seminar	2	Research, presentation and discussion	On-campus time Preparation and follow-up Examination preparation and Examination	30 70 50
Module exam:		Presentation with discussion (approx. 30 to 45 minutes) or written summation (approx. 10 pages)		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

Lecture module: Machine Learning in Bioinformatics

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Computer Science and Mathematics

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students are familiar with key statistical and algorithmic concepts in the field of machine learning and can situate and apply these within the context of current research in bioinformatics, biology and biotechnology. They are able to select suitable methods and models for specific issues and can evaluate and communicate the results.

Content:

Rotating topics in machine learning in the field of bioinformatics are considered in depth. These topics include:

Regularization methods for variable selections and regression methods for features decorrelation with application to mass spectroscopy data and cancer data

Support vector machines for tumor classification based on genomic data and clinical covariates

SVMs with string kernels to classify omics data, such as RNA sequences

Artificial neural networks (ANNs) and deep learning and some recent applications in bioinformatics

Graphical models for signal cascade analysis and quasi-species identification

Active learning with random forests applied to modern omics data, such as mass spectrometry or NGS

Unsupervised learning: model-based clustering of microRNA expression data

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 30 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	30 30

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Participation recommended	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Big Data Analysis in Bioinformatics

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students are familiar with key concepts in the area of (pre-)processing and analysis of large volumes of data and can situate and apply these in the context of bioinformatics and other life sciences. They are able to select suitable methods and models for specific issues and can evaluate and communicate the results.

Content:

The following topics are considered:

– Infrastructure and programming frameworks for analysis of very large data sets
– Data pre-processing and data quality
– Machine learning for very large data sets
– Analysis of stream data
– Analysis of very large networks

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü Preparation and follow-up, Ü Examination preparation and Examination	30 30 30 30 30
Exercise	2	Work on assigned exercises		

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes) or Work on a project with written summation (approx. 10 pages) with oral presentation (approx. 10 minutes)	
Module language:	English	
Mandatory regular participation:	Participation recommended	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Complex Data Analysis in Physiology

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students are familiar with current developments in the field of data processing, especially in the areas of imaging and electrophysiology, based on selected examples.

Content:

Theoretical and practical aspects of data acquisition, real-time data processing and automated pattern recognition in biomedicine. Topics from the following areas are considered in depth:

– Data collection and processing of image files in research and clinical settings (e.g., live cell imaging, super-resolution microscopy, imaging methods in medicine)
– Electrophysiological methods (e.g., impedance spectroscopy, microarrays, EEG, EKG)
– Methods and application of automated pattern recognition (e.g., automated tumor recognition, real-time analysis of biological signals in the brain-computer interface or in retinal implants, prediction of individual arrhythmia risks)

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 30 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	30 30

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Lecture: Participation recommended, exercise: Yes	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Each summer semester	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Methodology for Clinical Trials

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students have a deeper understanding of the design, implementation and statistical analysis of clinical studies.

Content:

This study program deals with statistical methods and the design of clinical studies. Fundamental aspects such as randomization, blind studies, definition of control groups and study end points as well as study types (efficiency, equivalence, bioequivalence, phase I, phase II, phase II) and principles of meta-analysis are discussed. The relevant statistical models and tests are presented. The goal of this course is to
form and shape statistical thinking in the context of clinical studies, which encompasses both the use of statistical tests and critical review of the experimental approach.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 30 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	30 30

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Lecture: Participation recommended, exercise: Yes	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Advanced Biometrical Methods

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students have an overview of the use of Monte Carlo simulations and are familiar with the subject area of group sequential and adaptive study designs – especially in a regulatory context. They are able to calculate the number of cases needed for a study using various methods and know the differences from traditional design without interim analysis.

Content:

Topics from the following areas are considered in depth:

– Case number planning

– Group sequential and adaptive study designs

– Monte Carlo simulations in methodological research and study planning

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 30 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	30 30

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Lecture: Participation recommended, exercise: Yes	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Special Aspects of Data Science in the Life Sciences

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students can apply the main terminology and results of a selected field of data science in the life sciences.

Content:

This module provides insight into a selected field of data science in the life sciences, for example in current methods used for data analysis in the field of biomedicine. In addition, it also covers research questions and application areas.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 30 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	30 30

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Participation recommended	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Selected Topics in Data Science in the Life Sciences

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students know the fundamentals in a specific area or application field of data science in the life sciences. They are able to apply what they have learned proficiently.

Content:

Rotating content, for example advanced methods for analysis of data from the life sciences.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	4	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	60 80 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	80 50

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Participation recommended	
Total working time requirement:	300 hours	10 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Practical module: Current Topics in Medical Genomics

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students are familiar with different computer science and statistical methods from the field of medical genomics and can apply them to solve a problem in integrative genomics from current research. They are capable of evaluating the results and comparing and evaluating them using computer models and scripts they develop. They can compare and assess the advantages and limitations of different methods and provide a critical estimation of the relevance of the results generated by the computer programs to an understanding of biological systems in a medical context.

Content:

Based on a genomic problem, computer science approaches to a solution are formulated using computer programs and scripts developed by the students to address research questions from current literature or derivative questions. The objective is to learn how integrative data analysis can be used to understand high-throughput data. Students are tasked with identifying topics from the current literature and developing scripts and/or programs to test and expand on sub-aspects.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Practical seminar	4	Work on assigned tasks, presentation of results	On-campus time Preparation and follow-up Examination preparation and Examination	60 70 20
Module exam:		Written presentation (approx. 5 pages) or oral presentation (approx. 15 minutes)		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

Practical module: Machine Learning in Bioinformatics

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Mathematics

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students can use standard programs, systems, and libraries independently in the field of machine learning for bioinformatics. They can use these building blocks to conceptualize complex workflows and implement them in a modern programming language. They can independently plan and implement methods that are lacking. They can interpret the results and develop them in graphic form.

Content:

The students get to know key statistical and algorithmic concepts in the field of machine learning, particularly in the context of current research in bioinformatics, biology and biotechnology. In the process, they work on various practical problems and apply and implement methods drawn from the lecture in order to use R to extract relevant information from biological data sets. In particular, they will learn how suitable models are selected for specific issues and how results can be evaluated and communicated. Students will approach what they have learned in depth through weekly exercises.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Practical seminar	4	Work on assigned tasks, presentation of results	On-campus time Preparation and follow-up Examination preparation and Examination	60 70 20
Module exam:		Written presentation (approx. 5 pages) or oral presentation (approx. 15 minutes)		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

2c. Profile study portion with a concentration in Advanced Algorithms

Module: Advanced Algorithms for Bioinformatics

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Computer Science

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students have acquired a deeper understanding of basic algorithmic concepts in the field of analysis of genomic sequences against the background of current research trends in bioinformatics and biotechnology. They understand various paradigms for approximate searches and know under what circumstances certain algorithms are to be preferred over others and are capable of assessing scientific publications in the field accordingly.

Content:

Topics from the following areas, among others, are considered in depth:

– Theoretical computer science
– Complexity theory
– Calculability
– Data structures for strings (compressed suffix arrays, approximate search, Bloom filter, de Bruijn graphs)
– Algorithms for RNA structure determination and structural alignment (2D, 3D)

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü Preparation and follow-up, Ü On-campus time, S Preparation and follow-up, S Examination preparation and Examination	30 70 30 30 30 80 30
Exercise	2	Work on assigned exercises		
Seminar	2	Seminar presentation		

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Lecture: Participation recommended, exercise and seminar: Yes	
Total working time requirement:	300 hours	10 credits
Duration of module:	One semester	
Frequency of offering:	Each winter semester	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Methods in Life Sciences

Higher education institution/department/teaching unit: Freie Universität Berlin/Biology, Chemistry and Pharmacy/Biology, Chemistry, Biochemistry and Pharmacy

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students have an advanced understanding of algorithmic problems occurring in conjunction with modern molecular biology data. They can adapt mathematical concepts and methods drawn from advanced algorithmics that they have already learned to the relevant data and independently evaluate and compare various methods of analyzing and interpreting these kinds of data.

Content:

Current developments in molecular biology and the algorithmic challenges they present.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, S	30 60 15
Seminar	1	Research, presentation and discussion	Preparation and follow-up, S Examination preparation and Examination	15 30

Module exam:	Presentation with discussion (approx. 15 to 30 minutes) or written summation (approx. 10 pages), or Written exam (60 minutes), which may be administered in whole or in part as a multiple choice test or as an electronic exam.	
Module language:	English	
Mandatory regular participation:	Lecture: Participation recommended, seminar: Yes	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Each summer semester	
Applicability:	Master's degree program in Bioinformatics	

Module: Biodiversity and Evolution

Higher education institution/department/teaching unit: Freie Universität Berlin/Biology, Chemistry, Pharmacy/Biology

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students have an overview of use of evolutionary bioinformatics and next-generation sequencing (NGS) in modern biodiversity research. They are familiar with the processes of gene and genome evolution and the basic principles of analysis of metagenomes and metatranscriptomes and their practical applications. They know which computer science methods are used in current biodiversity research and can assess which methods to use for which applications in these fields.

Content:

Topics from the following areas are considered in depth:

– Genome evolution, tree of life, evolution of populations
– Current applications of NGS in biodiversity research, including genomics and transcriptomics of "Non-model" organisms, metagenomics, DNA metabarcoding, population biology and population genetics, analysis of ecological commonalities (structure and function)

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 45 15
Exercise	1	Work on assigned exercises	Preparation and follow-up, Ü On-campus time, S Preparation and follow-up, S	60 30 60
Seminar	2	Research, presentation and discussion	Examination preparation and Examination	60

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Lecture: Participation recommended, exercise and seminar: Yes	
Total working time requirement:	300 hours	10 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Module: Structural Bioinformatics

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students are familiar with the current, research-related algorithms for analysis of biological structures. They are capable of assessing the strengths and weaknesses of different approaches and can independently discern which algorithms are appropriate for handling which analytical problems.

Content:

Topics from the following areas are considered in depth:

– Structure, function and dynamics of proteins
– Algorithms of molecular similarity and their application
– Methods for calculation of (multiple) local and global structural alignments
– Docking of organic microstructures to proteins as well as protein-protein docking

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on lecture content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü Preparation and follow-up, Ü On-campus time, S Preparation and follow-up, S Examination preparation and Examination	30 45 15 60 30 60 60
Exercise	1	Work on assigned exercises		
Seminar	2	Research, presentation and discussion		

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Lecture: Participation recommended, exercise and seminar: Yes	
Total working time requirement:	300 hours	10 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Module: Current Research Topics in Advanced Algorithms

Higher education institution/department/teaching unit:

Freie Universität Berlin/Mathematics and Computer Science/Mathematics and Computer Science,

Freie Universität Berlin/Biology, Chemistry and Pharmacy/Biology, Chemistry and Biochemistry as well as

Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students are familiar with current approaches in various subject fields in bioinformatics in the area of advanced algorithms and are able to apply the key algorithms and analyze and interpret the results obtained.

Content:

This seminar uses current publications from prestigious specialized journals or subject-specific conferences to present the latest research work from the field of bioinformatics in the area of advanced algorithms.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Seminar	2	Research, presentation and discussion	On-campus time Preparation and follow-up Examination preparation and Examination	30 70 50
Module exam:		Presentation with discussion (approx. 30 to 45 minutes) or written summation (approx. 10 pages)		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

Lecture module: Selected Topics in Advanced Algorithms

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Computer Science

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students know the fundamentals in a special area or an application area of advanced algorithms. They are able to apply what they have learned proficiently.

Content:

Rotating content, for example advanced aspects of analysis of multimodal, distributed data, modeling, simulation, optimization of omics experiments or machine learning.

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	4	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	60 80 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	80 50

Module exam:	Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)	
Module language:	English	
Mandatory regular participation:	Participation recommended	
Total working time requirement:	300 hours	10 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Lecture module: Special Aspects of Advanced Algorithms				
Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Computer Science				
Persons responsible for module: Module instructors				
Admission requirements: None				
Qualification objectives: Students can apply the main terminology and results of a selected field in advanced algorithms.				
Content: This module provides insight into a selected field of advanced algorithms, for example programming methods for large data volumes from the area of biomedicine. In addition, it also covers research questions and application areas.				
Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Lecture	2	Follow-up on VL content and independently developing supplementary literature	On-campus time, V Preparation and follow-up, V On-campus time, Ü	30 30 30
Exercise	2	Work on assigned exercises	Preparation and follow-up, Ü Examination preparation and Examination	30 30
Module exam:		Written exam (90 minutes); the written exam can also be taken electronically or as an oral exam (approx. 20 minutes)		
Module language:		English		
Mandatory regular participation:		Participation recommended		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

Practical module: Applied Sequence Analysis

Higher education institution/department/teaching unit: Freie Universität Berlin/Mathematics and Computer Science/Computer Science

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students can use standard sequence analysis programs independently. They are familiar with the different concepts and can operate and program selected systems.
They can design new workflows and present the results in graphic form.

Content:

Topics from the following areas are considered in depth:

– Implementations of distributed computing
– Incorporation of standard programs into workflows
– Generation and use of bioinformatics workflows in existing systems

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Practical seminar	4	Work on assigned tasks, presentation of results	On-campus time Preparation and follow-up Examination preparation and Examination	60 70 20
Module exam:		Written presentation (approx. 5 pages) or oral presentation (approx. 15 minutes)		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

Practical module: Environmental Metagenomics

Higher education institution/department/teaching unit: Freie Universität Berlin/Biology, Chemistry, Pharmacy/Biology

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

The students can collect and analyze genome data from environmental samples. They know how to take and store samples. They can prepare the samples for genome analysis independently and interpret and present the data obtained.

Content:

Topics from the following areas are considered:

– Environmental sampling
– Lab processing of samples (e.g., DNA extraction, molecular biology)
– Data analysis
– Presentation of the results

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Practical seminar	4	Work on assigned tasks, presentation of results	On-campus time Preparation and follow-up Examination preparation and Examination	60 70 20
Module exam:		Written presentation (approx. 5 pages) or oral presentation (approx. 15 minutes)		
Module language:		English		
Mandatory regular participation:		Yes		
Total working time requirement:		150 hours	5 credits	
Duration of module:		One semester		
Frequency of offering:		Irregular		
Applicability:		Master's degree program in Bioinformatics		

Practical module: Current Topics in Structural Bioinformatics

Higher education institution/department/teaching unit: Charité – Universitätsmedizin Berlin

Persons responsible for module: Module instructors

Admission requirements: None

Qualification objectives:

Students have gained practical experience in the application of current algorithms for analysis of biological structures. They recognize the strengths and drawbacks of different approaches and apply suitable algorithms to given analytical problems independently.

Content:

Topics from the following areas are considered in depth:

– Homology modeling of proteins
– In silico screening with subsequent substance evaluation and filtering (ADMETox)
– 3D superpositions, 3D QSAR, pharmacophore searches
– Use of GOLD and Accelrys in structure-based ligand design

Forms of teaching and learning	**On-campus studies** (weekly credit hours = SWS)	**Forms of active participation**	**Workload** (hours)	
Practical seminar	4	Work on assigned tasks, presentation of results	On-campus time Preparation and follow-up Examination preparation and Examination	60 70 20

Module exam:	Written presentation (approx. 5 pages) or oral presentation (approx. 15 minutes)	
Module language:	English	
Mandatory regular participation:	Yes	
Total working time requirement:	150 hours	5 credits
Duration of module:	One semester	
Frequency of offering:	Irregular	
Applicability:	Master's degree program in Bioinformatics	

Annex 2: Sample study plans for the master's degree program in Bioinformatics:

2.1 Master’s degree program in Bioinformatics with the profile area Complex Systems

<table>
<tr><th>Semester</th><th colspan="4">Fundamental study portion, 30 credits</th></tr>
<tr><td>1. FS
30 Credits</td><td>Module
Foundations in Computer Science
6 Credits</td><td>Module
Foundations in Mathematics and Statistics
6 Credits</td><td>Module
Foundations in Bio-Medicine
6 Credits</td><td>Module
Introduction to Focus Areas
12 Credits</td></tr>
<tr><td rowspan="4">2. FS
30 Credits</td><td colspan="3">Profile area, 30 Credits</td><td rowspan="2">Supplementary area, 15 Credits</td></tr>
<tr><td colspan="2">Mandatory area</td><td>Elective area</td></tr>
<tr><td>Module
Complex Systems in Bioinformatics
10 Credits</td><td>Module
Ethics and Policy Questions</td><td rowspan="2">Modules totaling 15 Credits*</td><td rowspan="2">Modules from the other profile areas totaling 15 Credits*</td></tr>
<tr><td>3. FS
30 Credits</td><td>Lecture
Complex Systems in Biomedical Applications
5 Credits</td><td>Module
Research Internship
10 Credits</td></tr>
<tr><td>4. FS
30 Credits</td><td colspan="4">Master’s thesis with accompanying colloquium
30 Credits</td></tr>
</table>

* In the elective area and the supplementary area, at least one lecture module and one practical module in all must be chosen and successfully completed.

2.2 Master's degree program in Bioinformatics with the profile area Data Science

<table>
<tr><th>Semester</th><th colspan="4">Fundamental study portion, 30 credits</th></tr>
<tr><td>1. FS
30 Credits</td><td>Module
Foundations in Computer Science
6 Credits</td><td>Module
Foundations in Mathematics and Statistics
6 Credits</td><td>Module
Foundations in Bio-Medicine
6 Credits</td><td>Module
Introduction to Focus-Areas
12 Credits</td></tr>
<tr><td rowspan="2">2. FS
30 Credits</td><td colspan="3">Profile area, 30 Credits</td><td rowspan="2">Supplementary area, 15 Credits</td></tr>
<tr><td colspan="2">Mandatory area</td><td>Elective area</td></tr>
<tr><td rowspan="2">3. FS
30 Credits</td><td rowspan="2">Module
Data Science in the Life Sciences
15 Credits</td><td>Module
Ethics and Policy Questions
5 Credits</td><td rowspan="2">Modules totaling 15 Credits*</td><td rowspan="2">Modules from the other profile areas totaling 15 Credits*</td></tr>
<tr><td>Module
Research Internship, 10 Credits</td></tr>
<tr><td>4. FS
30 Credits</td><td colspan="4">Master's thesis with accompanying colloquium
30 Credits</td></tr>
</table>

* In the elective area and the supplementary area, at least one lecture module and one practical module in all must be chosen and successfully completed.

2.3 Master's degree program in Bioinformatics with the profile area Advanced Algorithms

<table>
<tr><th>Semester</th><th colspan="4">Fundamental study portion, 30 credits</th></tr>
<tr><td>1. FS
30 Credits</td><td>Module
Foundations in Computer Science
6 Credits</td><td>Module
Foundations in Mathematics and Statistics
6 Credits</td><td>Module
Foundations in Bio-Medicine
6 Credits</td><td>Module
Introduction to Focus-Areas
12 Credits</td></tr>
<tr><td rowspan="2">2. FS
30 Credits</td><td colspan="3">Profile area, 30 Credits</td><td rowspan="2">Supplementary area, 15 Credits</td></tr>
<tr><td colspan="2">Mandatory area</td><td>Elective area</td></tr>
<tr><td rowspan="2">3. FS
30 Credits</td><td>Module
Advanced Algorithms for Bioinformatics
10 Credits</td><td>Module
Ethics and Policy Questions
5 Credits</td><td rowspan="2">Modules totaling 15 Credits*</td><td rowspan="2">Modules from the other profile areas totaling 15 Credits*</td></tr>
<tr><td>Lecture
Methods in Life Sciences
5 Credits</td><td>Module
Research Internship
10 Credits</td></tr>
<tr><td>4. FS
30 Credits</td><td colspan="4">Master's thesis with accompanying colloquium
30 Credits</td></tr>
</table>

* In the elective area and the supplementary area, at least one lecture module and one practical module in all must be chosen and successfully completed.

Annex 3: Grade report (sample)

Freie Universität Berlin
Charité – University Medicine Berlin

Report of Grades

[First name/Last name]

born on [Month DD, YYY] in [place of birth]

has successfully completed the master's degree program in

Bioinformatics

on the basis of the examination regulations of September 23, 2019 (Freie Universität Official Announcements 22/2019) with the overall grade of

[grade as number and text]

and earned the required number of 120 credits.

Evaluation of examination results:

Field(s) of study	Credits	Grade
Study phase	90 (63)	
Master's thesis	30 (30)	

The topic of the master's thesis was: [XX]

Berlin, this [Month DD, YYYY] (Seal)

The Chair of the Joint Commission The Chair of the Examining Board

Grading scale: 1.0 – 1.5 very good; 1.6 – 2.5 good; 2.6 – 3.5 satisfactory; 3.6 – 4.0 sufficient; 4.1 – 5.0 insufficient: Non-graded evaluations: BE – passed; NB – not passed
The credits awarded are in accordance with the European Credit Transfer and Accumulation System (ECTS).
Some coursework is not graded; the credits shown in parentheses reflect the scope of graded coursework that impacts the overall grade.

Annex 4: Diploma (sample)

Freie Universität Berlin
Charité – University Medicine Berlin

Certificate

[First name/Last name]

born on [Month DD, YYY] in [place of birth]

has successfully completed the master's degree program in

Bioinformatics

Based on the Examination Regulations of September 23, 2019 (Freie Universität Official Announcements No. 22/2019)

the university degree of

Master of Science (M. Sc.)

is awarded.

Berlin, this [Month DD, YYYY] (Seal)

The Chair of the Joint Commission

The Chair of the Examining Board

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