UNIVERSITÄT BAYREUTH

Faculty for Biology, Chemistry and Earth Sciences

Module Handbook

for the Master Program

„Natural Product and Drug Chemistry“

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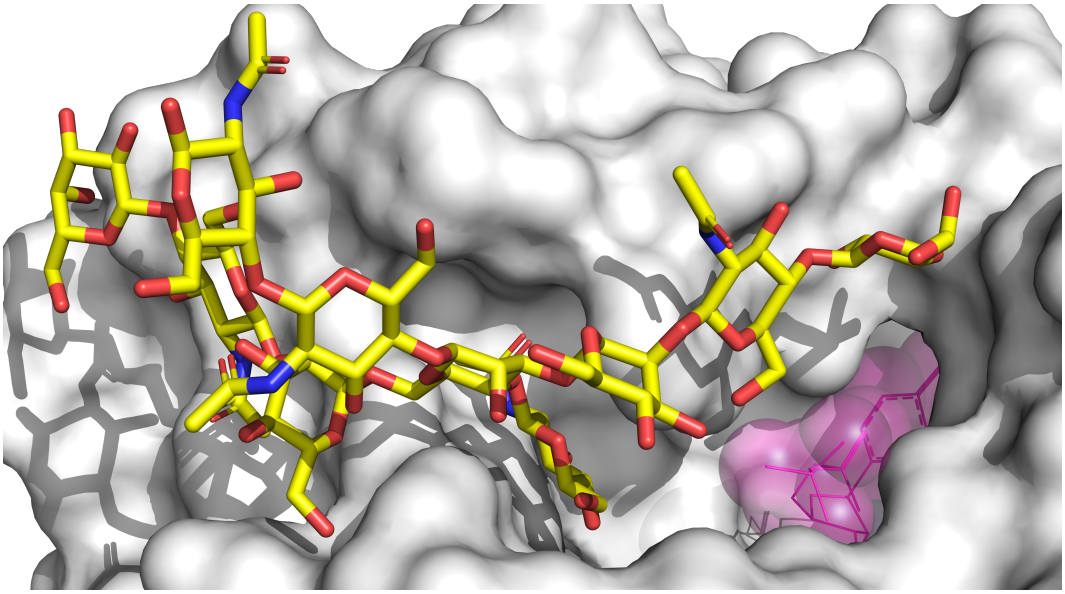

Content

Introduction and Overview

High-quality food and pharmaceuticals ensure our daily medical care, nutrition, and quality of life. Innovation in these fields, i.e. the development of new, tailor-made drugs, requires comprehensive knowledge of synthetic organic chemistry and a profound understanding of drug interactions with biological systems. The Master program in *Natural Product and Drug Chemistry* is centrally positioned in this broad subject area and also includes relevant aspects of the neighbouring sciences of biology, biochemistry, pharmacy and medicine. It provides in-depth knowledge about the synthesis, biosynthesis and analysis of natural products, drugs and functional substances, as well as the molecular principles of their interactions in a biological context. The structures and properties of biomolecules, be they small molecules ("ligands") or macromolecular targets ("targets"), also form a major part of the curriculum. The program thus combines the complex contents of modern synthetic chemistry with biological and medical-pharmaceutical aspects. The offered modules provide students with a multifaceted selection of choices, but also allow them to focus on a particular area. With the acquired competences, graduates are qualified for professional activities in research, development, production and services in the field of classical chemistry on the one hand. On the other hand, the interdisciplinary education opens attractive career prospects in the modern fields of life sciences, agricultural sciences and health care.

The Master program "*Natural Product and Drug Chemistry"* can be started either in the winter or summer semester. The *first-year modules* usually consist of lectures and practical laboratory courses to develop experimental skills in addition to theory. Seven modules are offered in the winter semester, four of which are from the field "Low-Molecular-Weight Natural Products and Drugs" (Biosynthesis of Natural Products; Catalysis and Sustainable Synthesis; Stereoselective Organic Synthesis; Homogeneous Catalysis) and three from the area "Macromolecular Targets and Structures" (Molecular Modelling; Chemometrics; Solid-state Inorganic Materials: Nanochemistry). Students will choose three modules from these. The fourth module can be chosen freely from the other chemistry courses offered in this or other Master programs in chemistry and related disciplines.

In the summer semester, six modules are offered, three of which are in the area of low-molecular-weight compounds (Alkaloids – Biosynthesis and Total Synthesis; Bioorganic Chemistry; Analytics and Screening of Natural Products and Drugs) and three in the biomacromolecular area (Basics of Bioinformatics; Biophysical Chemistry – Multidimensional NMR Spectroscopy of Biomacromolecules; (Bio-)Analytics: QM and

Metrology in the Chemical Laboratory). Students are free to choose three of them. In addition, students prepare a plan for their own scientific research project ("Research Plan"). The examinations for the modules of the first and second semesters are conducted either as oral or written examinations. The types of examination for each module are listed in the respective module description. Further details of the examinations (e.g. scope and duration of the examinations) can be found in § 11 of the Examination and Study Regulations (Prüfungs- und Studienordnung, PSO).

In the *third and fourth semester*, two advanced laboratory courses (research modules I and II) worth a total of 30 credits must be completed. One of these modules can be completed externally, e.g. as an industrial internship and/or abroad. The content of the Master thesis on a current topic in natural and medicinal product chemistry can already be chosen at the end of the second semester, so that independent scientific work on it is possible in parallel to the research modules, building on the module "Research Proposal" as preliminary work. The Master thesis, worth 30 credits, can thus be completed over a period of 12 months, with an increasing workload in the fourth semester.

A total of at least 120 credit points (winter semester: 28; summer semester: 32; 3rd & 4th semester: 60 in total) must be obtained in the Master program in *Natural Product and Drug Chemistry*. An overview of the courses offered in the Master program can be found in Appendix 1.

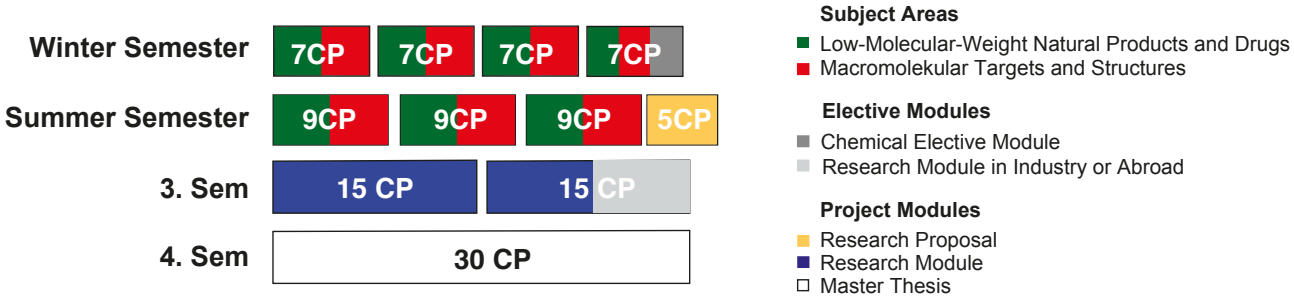

Figure: Modular Structure, Subject Areas, and Credit Points of the Master Program “Natural Products and Drug Chemistry”

Coordinator of the Master Program *Natural Product and Drug Chemistry:*

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Module B101: Biosynthesis of Natural Products

Responsible persons: Module: Prof. C. Unverzagt (Organic Chemistry II)
Lecture: Prof. C. Unverzagt, Prof. F. Hahn
Lab course: Lecturers of Organic Chemistry

Learning objectives:

Provides a deeper understanding of the biosynthetic pathways of natural products, their basic structural types and their relationship to biological activity.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	WS
• Lab course (3 weeks, block course, date by arrangement)	6	WS

Course content:

- **Lecture:** The general biosynthetic pathways for natural products are presented and those of the most important, such as fatty acids, amino acids, carbohydrates, nucleic acids, polyketides, terpenes, vitamins, alkaloids and their secondary metabolites, are discussed in detail. The interaction between humans and natural products is examined on the basis of selected examples.
- **Lab course:** Individual aspects of natural products chemistry are taught by working on a current research project in one of the participating working groups. The results are summarised in a report and presented in a seminar lecture.

Entrance requirements:

None.

Assessment:	Weighting
• Graded oral or written examination on the lecture	70%
• Graded lab course with report and seminar presentation	30%

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	120 hours
Total workload:	210 hours

***ECTS credit points:* 7**

Module B102: Catalysis and Sustainable Synthesis

Responsible persons: Module: Prof. S. Das (Organic Chemistry I)
Lecture: Prof. S. Das
Lab course: Lecturers of Organic Chemistry

Learning objectives:

Will provide deeper understanding of different catalysis aspects for the synthesis of pharmaceuticals, fine chemicals, monomers, and fuels.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	WS
• Lab course (3 weeks, block course, date by arrangement)	6	WS

Course content:

- **Lecture:** The general catalytic strategies will be discussed by keeping more focus onto photocatalysis, electrocatalysis and thermocatalysis. Basics of all these catalysis aspects will be exemplified along with their application for the synthesis of drug molecules. Additionally, activation of small molecules such as CO_2, O_2 will be discussed and their applications into organic synthesis will also studied. Furthermore, catalysis for the synthesis of monomer of polymers will be depicted in this course.
- **Lab course:** Individual aspects of catalysis and sustainable synthesis are taught by working on a current research project in one of the participating research groups. The results are summarized in a report and presented in a seminar lecture.

Entrance requirements:

None.

Assessment:	Weighting
• Graded oral or written examination on the lecture	70%
• Graded lab course with report and seminar presentation	30%

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	120 hours
Total workload:	210 hours

ECTS credit points: 7

Module B103: Stereoselective Organic Synthesis

Responsible persons: Module: Prof. F. Hahn (Organic Chemistry IV)
Lecture: Prof. M. Breuning, Prof. F. Hahn
Lab course: Lecturers of Organic Chemistry

Learning objectives:

Methods, concepts and reactions of modern stereoselective organic synthesis are taught at an advanced level.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	WS
• Lab course (3 weeks, block course, date by arrangement)	6	WS

Course content:

- **Lecture:** Important reactions and methods of stereoselective organic synthesis are covered. In the first part, which deals with diastereoselective methods, the fundamentals of stereoselective synthesis are taught and methods for the selective construction of *E*- and *Z*-configured alkenes and of stereocentres (e.g. additions to α-chiral carbonyl compounds and alkenes, aldol additions) as well as auxiliary-mediated procedures for the synthesis of enantiomerically pure compounds are presented. The second part focuses on enantioselective catalytic methods: biocatalysis, organocatalysis, reduction and oxidation processes, allylation/crotylation and ring closure reactions. The knowledge imparted is deepened by means of examples of natural substance syntheses and industrial processes.
- **Lab course:** Individual aspects of stereoselective organic syntheses are taught by working on a current research project in one of the participating research groups. The results are summarized in a report and presented in a seminar lecture.

Entrance requirements:

None.

Assessment:	Weighting
• Graded oral or written examination on the lecture	70%
• Graded lab course with report and seminar presentation	30%

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	120 hours
Total workload:	210 hours

ECTS credit points: 7

Module B104: Homogeneous Catalysis

Responsible persons: Module: Prof. R. Kempe (Inorganic Chemistry II)
Lecture: Prof. R. Kempe
Lab course: Lecturers of Inorganic Chemistry

Learning objectives:

The students gain insight into polymerization catalysis and improve their knowledge in organometallic chemistry.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	WS
• Lab course (3 weeks, block course, date by arrangement)	6	WS

Course content:

- **Lecture:** The following topics are discussed: reactivity of the metal carbon bond, catalytic applications of organometallic compounds and coordinative polymerizations.
- **Lab course:** The students will improve their skills in working with highly air and moisture sensitive compounds and use them in teamwork with PhD students and postdocs to address catalysis relevant questions.

Entrance requirements:

None.

Assessment:	Weighting
• Graded oral or written examination on the lecture	70%
• Graded lab course with report and seminar presentation	30%

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	120 hours
Total workload:	210 hours

ECTS credit points: 7

Module B201: Alkaloids – Biosynthesis and Total Synthesis

Responsible persons: Module: Prof. M. Breuning (Organic Chemistry III)
Lecture: Prof. M. Breuning
Lab course: Lecturers of Organic Chemistry

Learning objectives:

Extensive knowledge of the natural product class of alkaloids will be provided: their biogenesis, structures, biological/medical significance and total synthesis.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	SS
• Lab course (4 weeks, block course, date by arrangement)	8	SS

Course content:

- **Lecture:** The focus is on the natural product class of alkaloids, which is characterized by multifaceted biosynthetic pathways and high structural diversity and complexity. After an introduction to general methods for the elucidation of biosynthetic pathways and a basic overview of this broad class of natural products, the four major alkaloid classes, the ornithine-, lysine-, phenylalanine/tyrosine- and tryptophan-derived alkaloids, as well as alkaloids of other origins will be discussed in detail: Typical representatives of the individual classes and their mostly plant-derived producers are presented; the biosynthesis of the alkaloids, starting from the basic building blocks via the central intermediates to the corresponding natural products, is outlined. Important drugs derived from highly bioactive alkaloids, their structural commonalities with the lead compound and their mechanisms of action are shown. Elegant and pioneering chemical total syntheses of selected alkaloids are presented and discussed step by step.
- **Lab course:** Individual aspects of natural product chemistry are taught by working on a current research project in one of the participating research groups. The results are summarized in a report and presented in a seminar lecture.

Entrance requirements:

None.

Assessment:	Weighting
• Graded oral or written examination on the lecture	60%
• Graded lab course with report and seminar presentation	40%

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	180 hours
Total workload:	270 hours

ECTS credit points: **9**

Module B202: Bioorganic Chemistry

Responsible persons: Module: Prof. C. Unverzagt (Organic Chemistry II)
Lecture: Prof. C. Unverzagt
Lab course: Dr. C. Pöhner

Learning objectives:

Based on the structure, properties and synthesis of biomacromolecules, an interdisciplinary approach is used to demonstrate the potential of targeted modification of biomolecules for biomedical purposes.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	SS
• Lab course (4 weeks, block course, fixed date)	8	SS

Course content:

- **Lecture:** The major classes of biomacromolecules are introduced and modern synthetic methods and the biological significance of each class are discussed in detail. Topics covered in detail include Biologically Active Peptides, Chemical and Enzymatic Synthesis of Amino Acids and Peptides, Analytical Methods for the Separation and Characterisation of Biomolecules, Solid Phase Synthesis, Protein Synthesis, Carbohydrates, Nucleic Acids.
- **Lab course:** Theoretical knowledge will be reinforced by experiments on the following topics Solid phase and peptide synthesis, enzymatic reactions, structural characterisation of products using spectroscopic methods.

Entrance requirements:

The module can only be chosen if the module Bioorganic Chemistry has not been attended in the Bachelor's study program.

Assessment:	Weighting
• Graded oral or written examination on the lecture	60%
• Graded lab course with report	40%

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report	180 hours
Total workload:	270 hours

ECTS credit points: **9**

Module B203: Analytics and Screening of Natural Products and Drugs

Responsible persons: Module: Dr. U. Lacher (Organic Chemistry I)
Lecture: Dr. U. Lacher
Lab course: Dr. U. Lacher

Learning objectives:

Knowledge is taught on the isolation, quantification and screening of natural products and drugs.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	SS
• Lab course (4 weeks, block course, fixed date)	8	SS

Course content:

- **Lecture:** Methods for extraction, isolation, separation and quantification (GC, HPLC), as well as for structure analysis (spectroscopy) of natural products and drugs are presented. In addition, the most important methods for screening for various types of activity are discussed, e.g. fluorimetric assays for cytotoxicity, inhibition of specific enzymes and proteins, and cell morphological changes; agar diffusion tests for antibiotic activity; immunoblotting and electrophoresis for the quantification of DNA and proteins.
- **Lab course:** The methods are exercised on selected, standardised separation and screening problems and are intensified by participation in some of the current research projects of the involved working groups as well as by a lecture on a current topic.

Entrance requirements:

None.

Assessment:	Weighting
• Graded oral or written examination on the lecture	60%
• Graded lab course with report and seminar presentation	40%

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	180 hours
Total workload:	270 hours

***ECTS credit points:* 9**

Module B105: Molecular Modelling

Responsible persons: Module: Prof. M. Ullmann (Biochemistry V)
Lecture: Prof. M. Ullmann
Lab course: Prof. M. Ullmann

Learning objectives:

Starting from the structure, properties and synthesis of biomacromolecules, an interdisciplinary approach is taken to demonstrate the potential of targeted modification of biomolecules for biomedical purposes.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	WS
• Lab course (2 weeks, block course, fixed date)	6	WS

Course content:

- **Lecture:** The theoretical basics of molecular modelling (molecular force fields, biomolecular electrostatics, classical and statistical mechanics), their numerical implementations (molecular dynamics simulations, energy minimisation and normal mode analysis, Monte Carlo simulations), basics of quantum chemical methods as well as the modelling of biochemical reactions and ligand binding are covered.
- **Lab course:** Various techniques (including analysis of biomolecular structures, calculation of electrostatic properties of biomolecules, normal mode analysis and introductory quantum chemical methods) will be applied to selected case studies to teach students the practical application of these methods.

Entrance requirements:

Basic knowledge of structural biochemistry and basic knowledge of UNIX for the practical course are strongly recommended. The module can only be selected if the module Molecular Modelling has not been attended in the Bachelor's degree program.

Assessment:	Weighting
• Graded oral or written examination on the lecture	100%
• Successful participation in the ungraded lab course with protocol	

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report	120 hours
Total workload:	210 hours

***ECTS credit points:* 7**

Module B106: Chemometrics

Responsible persons: Module: Prof. S. Schwarzinger (NMR center)
Lecture: Prof. S. Schwarzinger
Lab course: Prof. S. Schwarzinger

Learning objectives:

The module gives an overview of chemometrics, i.e. the analysis of chemical data using statistical methods (including AI), and in this context important spectroscopic techniques and their chemometric application in chemistry, food testing and medical diagnostics. Participants will acquire basic knowledge that will enable them not only to understand research work in the field of chemometrics, but also to carry it out independently.

Course units and temporal allocation:	HPW	Semester
• Lecture (block course)	2	WS
• Lab course (2 weeks, block course, fixed date)	5	WS

Course content:

- **Lecture:** Overview of chemometrics – from its beginnings to AI. Specifics of application to spectroscopic data (e.g.: IR, MS, NMR, isotope ratios, trace elements, etc.). Experimental basics: from sample preparation to final model. Overview of classification and regression methods and related data pretreatment. Introduction to the development of non-directional analytical methods and corresponding validation concepts. Application examples: from inorganic chemistry to food analysis (authenticity analysis) and diagnostics. Topic-related exercises complement the lecture.
- **Lab course:** Students learn to prepare, evaluate and critically interpret spectroscopic data for chemometric evaluations. Part of the lab course is a seminar with a graded presentation.

Entrance requirements:

Basic theoretical and practical knowledge in chemistry, especially in analytics and spectroscopy.

Assessment:	Weighting
• Graded oral or written examination on the lecture	70 %
• Lab course with report and seminar presentation	30 %
•	

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	120 hours
Total workload:	210 hours

ECTS credit points: 7

Module B107: Solid-State Inorganic Materials: Nanochemistry

Responsible persons: Module: Prof. J. Breu (Inorganic Chemistry I)
Lecture: Prof. J. Breu, Prof. J. Senker
Lab course: Lecturers of Inorganic Chemistry

Learning objectives:

The main aim of this module is to provide a sound and broad knowledge about current developments of solid inorganic materials with a focus on nanochemistry.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	WS
• Lab course (3 weeks, block course, date by arrangement)	6	WS

Course content:

- **Lecture:** During the lecture properties, applications and theoretical considerations of solid inorganic functional materials will be presented. Special care will be given to mechanistic aspects of synthetic routes as well as to modern strategies of characterization. The following items will be discussed: i) Inorganic Nanotechnology including the build-up of inorganic colloids, pigments, nano-rods and -wires. ii) Inorganic composite and filling materials including biogenic minerals like nacre and bone tissue. iii) Crystal engineering and polymorphism of molecular systems as well as their influence on drug design. iv) Supramolecular inorganic chemistry and host guest systems. v) Semi-crystalline and amorphous materials including glasses, glass ceramics, phase change materials and photonic crystals.
- **Lab course:** The students will deepen their practical skills by working with PhD students and postdocs in the group of the lecturers.

Entrance requirements:

None.

Assessment:	Weighting
• Graded oral or written examination on the lecture	70%
• Graded lab course with report and seminar presentation	30%

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	120 hours
Total workload:	210 hours

ECTS credit points: 7

Module B204: Basics of Bioinformatics

Responsible persons: Module: Prof. M. Ullmann (Biochemistry V)
Lecture: Prof. M. Ullmann
Exercise: Prof. M. Ullmann
Essay: Prof. M. Ullmann

Learning objectives:

Students should acquire the fundamentals of bioinformatics and learn about the major applications in theory and practice.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	SS
• Exercise (1 week, block course, fixed date)	2	SS
• Work report	6	SS

Course content:

- **Lecture:** The fundamentals of the links between information and biology will be presented. The focus will be on the application of information-theoretical methods to the analysis of molecular biological data (databases and database searching, sequences and sequence alignments, phylogenetic trees), as well as the fundamentals of molecular modelling, structure prediction and drug design.
- **Exercise:** Students will learn to apply various computational methods to practical examples (use of the Internet to apply bioinformatics methods, use of web-based databases, sequence alignment, molecular modelling, visualisation of biomolecular structures, analysis of metabolic networks).
- **Work report:** Students will write a small essay on a topic in bioinformatics (10 to 15 pages). The students will also have the chance to apply their skills in literature and information search.

Entrance requirements:

Basic knowledge of biochemistry

Assessment:	Weighting
• Graded oral examination on the lecture	70%
• Graded work report	30%
• Successful participation in the ungraded exercise	

The module grade will only be given after successful completion of all parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Exercise	60 hours
• Essay with seminar presentation	120 hours
Total workload:	270 hours

ECTS credit points: **9**

Module B205: Biophysical Chemistry – Multidimensional NMR Spectroscopy of Biomacromolecules

Responsible persons: Module: Dr. K. Schweimer (Biochemistry IV)
Lecture: Dr. K. Schweimer
Lab course: Dr. K. Schweimer

Learning objectives:

Theoretical knowledge and practical skills of modern methods of NMR spectroscopy for the analysis of biomacromolecules.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	SS
• Exercises	2	SS
• Lab course (2 weeks, block course, fixed date)	5	SS

Course content:

- **Lecture:** Knowledge and techniques of NMR spectroscopy of biomacromolecules are taught: Quantum mechanical description of NMR experiments (product operator formalism), two- and higher-dimensional homo- and heteronuclear correlation experiments, triple resonance experiments for isotopically labelled proteins, cross relaxation and NOESY experiments, assignment of backbone and side-chain resonances of proteins, Fourier transposition and data processing, structure dependence of NMR parameters.
- **Lab course:** Practical work and exercises on the following topics will be carried out and intensified Performing various NMR experiments on the spectrometer (1D and 2D spectra), assigning the 3D spectra of a small protein.

Entrance requirements:

None. Basic knowledge in physical chemistry is recommended.

Assessment:	Weighting
• Graded oral or written examination on the lecture	100%
• Successful participation in the ungraded lab course with protocol and in the exercises	

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	180 hours
Total workload:	270 hours

***ECTS credit points:* 9**

Module B206: (Bio-)Analytics: QM and Metrology in the Chemical Laboratory

Responsible persons: Module: Prof. S. Schwarzinger (NMR center)
Lecture: Prof. S. Schwarzinger
Lab course: Prof. S. Schwarzinger

Learning objectives:

Acquisition of theoretical and practical knowledge in (bio)analytics, especially the basics of the analytical process and metrology (science of measurement). In connection with this, an overview of quality management, selected analytical techniques and OMICS is given.

Course units and temporal allocation:	HPW	Semester
• Lecture	2	SS
• Lab course (2 weeks, block course, fixed date)	7	SS

Course content:

- **Lecture:** Analytics is a metrological (measuring) science. This lecture introduces the analytical process and the fundamentals of metrology and results evaluation, and provides an overview of closely related quality management in the laboratory. Applications and fundamentals from the fields of spectroscopy (e.g.: qNMR as an example of quantitative reference method, IR etc.), separation methods and mass spectrometry are presented, as well as an introduction to OMICS methods with focus on metabonomics. Topic-related exercises complement the lecture.
- **Lab course:** Students learn to view the analytical process in its entirety, to interpret analytical results critically and to formulate them in a legally sound manner. Part of the lab course is a seminar with a graded presentation.

Entrance requirements:

Basic theoretical and practical knowledge in chemistry, especially in analytics and spectroscopy.

Assessment:	Weighting
• Graded oral or written examination on the lecture	55 %
• Graded lab course with report and seminar presentation	45 %

The module grade will only be given after successful completion of both parts.

Student workload:

• Lecture: 2 hours plus 2 hours preparation and wrap-up for 15 weeks	60 hours
• Exam preparation	30 hours
• Lab course with report and seminar presentation	180 hours
Total workload:	270 hours

ECTS credit points: **9**

Elective Modules

An additional module with 7 ECTS credit points must be taken. This module can be taken from the other chemical courses offered in this program or from another chemically or biologically oriented Master program at the University of Bayreuth, in particular

- Natural Product and Drug Chemistry,
- Biochemistry and Molecular Biology,
- Materials Chemistry and Catalysis,
- Polymer Science,
- Food and Health Sciences,
- Biodiversity and Ecology,
- Geoecology - Environmental Sciences,
- Molecular Ecology.

***ECTS credit points:* 7**

Module B210: Research Proposal

Responsible persons: Module: a lecturer involved in the lecture canon*

Learning objectives:

Students will acquire core competencies for independent scientific research by being guided to plan a project, to acquire the scientific literature, and to present the research results and the project in oral and written form.

Course units and temporal allocation:	HPW	Semester
• Writing a research proposal	8	2
• Seminar on the research topic	1	2

Course content:

Students prepare a written research proposal, in which the research area of a planned thesis is described and the scientific problem and experimental approach to solve it are outlined, in order to acquire competences in planning scientific projects. They are guided to independently develop the basics of a research area and the experimental methodology based on the scientific literature. The research plan is presented in a seminar to train presentation skills.

It is recommended to use the research proposal as a preparation for the forthcoming Master thesis.

Entrance requirements:

None.

Assessment:	Weighting
• Graded written research proposal	60%
• Graded oral presentation in the group seminar	40%

The module grade will only be given after successful completion of both parts.

Student workload:

• Group seminar with oral presentation including preparation and wrap-up	30 hours
• Writing a research proposal	120 hours
Total workload:	150 hours

ECTS credit points: **5**

* Other lecturers may be accepted upon prior application, provided that
- the topic of the planned research plan corresponds to the objectives of the Master degree program,
- the examination board approves him/her before the start of the research plan.

If you are planning a research project with a lecturer outside the Master program, please contact the chair of the examination board at least one month in advance.

Modules B301 and B302:* Research Module I and II

Responsible persons: Module: a lecturer involved in the lecture canon

Learning objectives:

Students should gain an insight into the research practice of chemical working groups and acquire and train experimental skills through independent laboratory work under supervision. The ability to work in a team will be practised and presentation techniques will be acquired and tested.

Course units and temporal allocation:	HPW	Semester
• Research project	19	3/4
• Group seminar presentation	1	3/4

Course content:

The course covers a current research project of the chosen working group. The module includes experimental work in the laboratory, literature search, and participation in the group seminar. The research results are presented in a written report and an oral presentation with discussion.

Entrance requirements:

None.

Assessment:	Weighting
• Graded lab course with a report.	80%
• Graded oral presentation in the group seminar.	20%

Student workload:

• Laboratory work including preparation and wrap-up	350 hours
• Group seminar with oral presentation including preparation and wrap-up	100 hours
Total workload:	450 hours

ECTS credit points: **15**

* One of the two research modules can be done externally, e.g. abroad, in industry, in an external research institute or in a working group at the University of Bayreuth that is not part of the lecture canon, provided that

- the topic of the planned research module corresponds to the objectives of the Master program,
- a lecturer from the University of Bayreuth who is involved in the lecture canon is available as a supervisor, and
- the examination board approves the external research module before it starts.

If you are planning to do an external research module, please contact the chair of the examination board at least one month in advance.

Module B400: Master Thesis*

Responsible persons: Module: a lecturer involved in the lecture canon

Learning objectives:

Students are expected to work independently on a research project under supervision and to report their findings in writing.

Course units and temporal allocation:	Semester
Work on a research project and prepare a written thesis	3/4

Course content:

The learning content relates to the current research projects of the chosen working group.

Entrance requirements:

According to the examination regulations, 45 credit points from finished modules are required.

Assessment:

Written version of the Master thesis.

Student workload:

Total workload: 900 hours

ECTS credit points: **30**

* In exceptional cases, the Master thesis can be done externally, e.g. abroad, in industry, in an external research institute or in a working group at the University of Bayreuth that is not part of the lecture canon, provided that

- the topic of the planned research module corresponds to the objectives of the Master program,
- a lecturer from the University of Bayreuth who is involved in the lecture canon is available as a supervisor and
- the examination board approves the external Master thesis before it starts.

If you are planning to undertake an external Master thesis, please contact the chair of the examination board at least one month in advance.

Appendix 1: Module Overview

Winter Semester (28 CP)*

Field	Low-Molecular-Weight Natural Products and Drugs				Macromolecular Targets and Structures			Elective Module#
Title	Biosynthesis of Natural Products	Catalysis and Sustainable Synthesis	Stereoselective Organic Synthesis	Homogeneous Catalysis	Molecular Modelling	Chemometrics	Solid-state Inorganic Materials: Nanochemistry	
Module	B 101	B 102	B 103	B 104	B 105	B 106	B 107	
CP	7	7	7	7	7	7	7	7
V (HPW)	2	2	2	2	2	2	2	
P (HPW)	6	6	6	6	6	5	6	
Selection	**3 of 7**							**1**

The elective module can be chosen from the other chemical courses offered in this program or from other chemical and biological Master programs at the University of Bayreuth.

Summer Semester (32 CP)*

Field	Low-Molecular-Weight Natural Products and Drugs			Macromolecular Targets and Structures			Research Proposal
Title	Alkaloids – Biosynthesis and Total Synthesis	Bioorganic Chemistry	Analytics and Screening of Natural Products and Drugs	Basics of Bioinformatics	Biophysical Chemistry – Multidimensional NMR Spectroscopy of Biomacromolecules	(Bio-)Analytics: QM and Metrology in the Chemical Laboratory	
Module	B 201	B 202	B 203	B 204	B 205	B 206	B210
CP	9	9	9	9	9	9	5
V (HPW)	2	2	2	2	2	2	9
P (HPW)	8	8	8	8	7	7	
Selection	**3 of 6**						**---**

3./4. Semester (60 CP including Master Thesis)*

Title	Research Module I#	Research Module II#	Master Thesis
Module	B 301	B 302	B 400
CP	15	15	30
S (HPW)	1	1	900 hours
P (HPW)	19	19	

One research module can be completed externally, e.g. abroad, in industry, at an external research institute or in a research group at the University of Bayreuth that is not involved in the lecture canon.

* CP = credit points; V = lecture; P = lab course; S = seminar HPW = hours per week