LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Module Handbook

Master's program: Pharmaceutical Sciences (Master of Science, M.Sc.)

(120 ECTS credit points)

Based on the Examination & Study Regulations, dated July 23, 2012

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Stand: June 1, 2021

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Abbreviations and Explanation of Terms

CP	Credit points, ECTS points
ECTS	European Credit Transfer and Accumulation System
h	Hours
SS	Summer semester
SWS	Periods per week
WS	Winter semester

1. With regard to the respective details on ECTS credit points, the descriptions of the allocated sub-modules are listed as follows: ECTS credit points which are not shown in brackets will be credited when you pass the exam for the respective module/sub-module. ECTS credit points in brackets are stated solely for classification purposes.

2. Depending on the specifications detailed in attachment 2 of the Examination & Study Regulations, information on timelines within the degree course may be mandatory or simply a recommendation. In the module guide, the terms “standard semester” and “recommended semester” are used for differentiation purposes in this context.

3. Please note: The module guide aims to provide you with a “road map” for your degree course. For binding rules and regulations, please refer solely to the updated version of your respective Examination & Study Regulations. You will find these at www.lmu.de/studienangebot, listed under your respective degree course.

Module: P 1 Pharmacology and toxicology

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Lecture	P 1.1 Advanced integrated pharmacology, Field A	WS	45 h (3 SWS)	45 h	(3)
Laboratory placement	P 1.2 Molecular and clinical aspects of pharmacology	WS	90 h (6 SWS)	90 h	(6)
Lecture	P 1.3 Advanced integrated pharmacology, Field B	SS	45 h (3 SWS)	45 h	(3)

In this module, students must acquire a total of 12 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 360 hours are required.

Module type	Mandatory module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	None
Prerequisites for participation	None
Semester of degree course	Standard semester: 1
Duration	This module lasts for 2 semesters.
Contents	In this **module**, students are introduced to the basic pathophysiological principles of disease processes, the basic molecular and cellular principles of how drug substances work, and the basic principles of toxicology. Following on from this, students learn the mechanisms of how drug substances work and pharmacotherapy for important illnesses. Further, the module focuses on modern strategies for explaining disease mechanisms and defining targets for drug substances. In a **cycle of lectures** extending over four semesters of the Pharmaceutical Sciences bachelor and master degree courses, the following topics are covered (selection): autonomic nervous system, endocrine system, heart, circulatory system, lungs, blood, kidney, gastrointestinal tract, CNS, eyes, pain, immune system, inflammation, contagious diseases, and tumors. In the **laboratory placement**, students form small groups and explore in more depth the insights gained during the lectures on disease mechanisms and drug therapy through practical applications which include clinical case studies. Here, students learn to take a methodological approach to solving complex

	pharmacological problems. Presentation, discussion and teamwork skills are also developed. Topics include: • treatment regimens for important diseases • case-related therapy management • risk/benefit assessment for specific active substances • assessing reciprocal effects
Qualification goals	On completion, students should be able to • explain the pathophysiological context of disease processes and the molecular and cellular mechanisms of pharmaceutical effects. • recognize and make a differentiated analysis of the basic strategies for explaining disease mechanisms and defining targets for drug substances. • integrate knowledge from the fields of pharmacology and toxicology, and apply it in order to solve complex questions and problems. • confidently deploy basic experimental pharmacological methods and work methods. • plan, conduct, evaluate, and document pharmacological experiments (supervised), and interpret the results. • suggest scientifically reasonable approaches and solutions for clinical situations, taking social and ethical considerations into account.
Type of module examination	Written or oral examination
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. Martin Biel
Language(s) of instruction	German
Other information	Not specified

Module: P 2 Pharmaceutical biology and biotechnology

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	P 2.1 Development of biogenic drug substances	WS	135 h (9 SWS)	135 h	9
Seminar	P 2.2 Molecular pharmaceutics	WS	45 h (3 SWS)	45 h	3

In this module, students must acquire a total of 12 ECTS credit points. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 360 hours are required.

Module type	Mandatory module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	None
Prerequisites for participation	None
Semester of degree course	Standard semester: 1
Duration	This module lasts for 1 semester.
Contents	In this **module**, students build on the biological and biochemical insights gained in their bachelor degree course to learn basic principles for developing biogenic and biotechnological pharmaceutical drugs. The module centers around genomics and proteomics, and also offers an introduction to the cellular testing of active substances (High Content Screening). During the **laboratory placement**, students learn the basic techniques for cell culture, e.g., working in sterile conditions, splitting or counting cells, and practice methods for the cellular testing of active substances, e.g., cytotoxity tests or reporter gene assays. The placement focuses particularly on testing natural substances. In the **seminar**, students look at recently published/presented molecular approaches for biotechnology, nanotechnology, genomics, and proteomics, to explore how innovative pharmaceutical drugs (molecular pharmaceutics, e.g., RNA-based therapeutic agents) are developed and characterized.
Qualification goals	On completion, students should be able to • integrate knowledge in the fields of pharmaceutical biology and biotechnology and apply it in order to solve complex problems and questions in new, unfamiliar

	contexts. • explain the theoretical, methodological, and instrumental contexts of biological assays. • understand the basic work methods used in molecular biology, e.g., working safely with cell cultures, Western Blot or the amplification of plasmids. • plan, conduct (under supervision), evaluate, and document the functional testing of active substances, and critically interpret the results. • talk in a qualified manner about recent international publications in the field of molecular pharmaceutics, discerningly evaluating and discussing their respective strengths and weaknesses. • develop their own ideas in research contexts.
Type of module examination	P 2.1 Written or oral examination, P 2.2 Presentation
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. Angelika Vollmar, Prof. Dr. Ernst Wagner, Prof. Dr. Stefan Zahler
Language(s) of instruction	P 2.1 German, P 2.2 English
Other information	Not specified

Module: P 3 Pharmaceutical technology and biopharmacy

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	P 3.1 Sterile types of pharmaceutical drugs, protein formulation, biomaterials	WS	30 h (2 SWS)	30 h	(2)
Seminar	P 3.2 Types of sterile pharmaceutical drugs, protein formulation, biomaterials	WS	15 h (1 SWS)	15 h	(1)
Lecture	P 3.3 Biopharmacy, Field A	WS	15 h (1 SWS)	15 h	(1)
Seminar	P 3.4 Quality control	WS	15 h (1 SWS)	15 h	(1)
Seminar	P 3.5 Biopharmacy	SS	30 h (2 SWS)	30 h	(2)
Lecture	P 3.6 Biopharmacy, Field B	SS	30 h (2 SWS)	30 h	(2)

A total of 9 ECTS credit points must be acquired in the module. Compulsory attendance: 9 periods per week during the semester. Taking personal studies into account, around 270 hours are required.

Module type	Mandatory module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	None
Prerequisites for participation	None
Semester of degree course	Recommended semester: 2
Duration	This module lasts for 2 semesters.
Contents	The **module** builds on the elementary lectures and laboratory placements for pharmaceutical technology completed during the bachelor's degree course, and covers the following topics: • biopharmacy, including the basic principles of pharmacokinetics, practical applications from biopharmacy and drug delivery relating to various types of pharmaceutical drugs. • basic quality control principles in the industrial manufacture of pharmaceutical drugs • sterile processing, protein galenics and protein analysis, biomaterials In the **lectures**, students learn the basic principles of biopharmacy, including the following topics: • pharmacokinetic models • the biopharmaceutical relevance of release, resorption,

distribution, and metabolism
- bioequivalence
- biopharmaceutical aspects relating to various types of pharmaceutical drugs

In the **biopharmacy seminar**, students explore the basics in more depth, using mathematical exercises and relevant examples to practice answering important pharmacokinetic questions such as blood level progression, maintenance doses, resorption mechanisms or evaluating bioavailability.

In the **laboratory placement**, students work in small groups on scientific questions concerning protein galenics, biomaterials, and sterile processing. In doing so they use modern analysis methods such as amortized analysis or implant manufacture, or work in a GMP-approved sterile laboratory. The **seminar** accompanying the laboratory placement explores the subjects in more depth, using relevant examples from the industry as illustrations.

In the **Quality control seminar**, students are introduced to current quality requirements in the manufacture of pharmaceutical drugs, explained using practical examples.

In the above seminar, guest speakers and lecturers from the industry link the theory closely to practice.

Qualification goals

On completion, students should be able to

- outline and evaluate scientific questions and approaches in the fields of
    - pharmacokinetics, bioavailability, resorption mechanisms, metabolism, factors which influence the bioavailability and pharmacokinetics for various types of pharmaceutical drugs, in vitro testing systems for biopharmaceutical parameters
    - quality control systems, EU-GMP guidelines, basic principles of validation, inspection systems, durability testing
    - polymer-based drug delivery systems, pulmonal, nasal, and buccal administration of drug substances, basic principles of sterile processing, important tools and areas of application for biomaterials

  and to apply these to new and unfamiliar questions and problems.
- understand and appropriately apply the basic analytical methods and manufacturing processes used in pharmaceutical technology and biopharmacy for sterile processing, protein formulation and biomaterials.
- plan, conduct, and evaluate pharmaceutical engineering experiments, document the results in a scientific protocol, and interpret and critically assess the results.

	• apply cleanroom work methods in conformance with GMP standards. • size up typical challenges in the fields of sterile processing, protein formulation, and biomaterials. • engage on complex, advanced research or development tasks in the above listed fields (supervised), using knowledge acquired during lectures as well as from further reading.
Type of module examination	Written or oral examination
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. Gerhard Winter, Prof. Dr. Wolfgang Frieß
Language(s) of instruction	German
Other information	Not specified

Module: P 4 Medical chemistry and pharmaceutical analysis

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Lecture	P 4.1 Drug design	WS	45 h (3 SWS)	45 h	(3)
Seminar	P 4.2 Molecular modeling	WS	15 h (1 SWS)	15 h	(1)
Laboratory placement	P 4.3 Drug monitoring and analysis of active substances	SS	120 h (8 SWS)	120 h	(8)

In this module, students must acquire a total of 12 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 360 hours are required.

Module type	Mandatory module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	None
Prerequisites for participation	None
Semester of degree course	Recommended semester: 2
Duration	This module lasts for 2 semesters.
Contents	In this **module**, students are introduced to the basic principles of drug design, including computer-based methods, testing of active substances, and analysis of drug substances in biological matrices. In the **lectures**, students are introduced to the basic concepts of developing active substances in medical chemistry. The lectures cover a representative selection of the methods and techniques used in drug discovery, from hit identification through to lead optimization. Topics include: • the kinetic and thermodynamic aspects of target ligand interaction • basic principles and methods of drug substance screening • analysis of structure-activity relationships and theoretic concepts for optimizing drug substances In the **seminar**, students are introduced to computer-based methods for developing drug substances. This is supported by practical exercises. The seminar is divided into two parts. The first part covers the modeling and comparison of small molecules, as well as ligand-based concepts such as

	pharmacophore hypotheses and QSAR analyses. The second part extends the concepts learned to structure-based methods such as homology modeling and docking. In the **laboratory placement**, students are introduced to important techniques for solving relevant questions in the field of medical chemistry and developing pharmaceutical drug substances. Building on existing analytical chemistry skills, students explore the physico-chemical and pharmacokinetic properties of drug substances with detection techniques (such as UV, HPLC/UV) typically applied for this purpose. In order to characterize biological activity, students test interactions of drug substances with their macromolecular targets , using modern fluorescence or luminescence based in-vitro-assays. Finally, students develop and apply methods for the LC-MS/MS-based quantification of drug substances in biological matrices, and validate sub-aspects of these in accordance with relevant regulations such as the FDA's CDER Guidance.
Qualification goals	On completion, students should be able to • outline the essential concepts of pharmaceutical drug development, assess these with regard to their possibilities and limitations, and utilize these when looking at new and unfamiliar questions and problems. • grasp and apply the basic methods of molecular modeling. • plan, conduct, and evaluate medical chemistry experiments using methods from literature, to document the results in a scientific protocol, and to interpret and assess the results. • characterize and assess drug substances for their suitable physico-chemical and pharmacokinetic properties with suitable methods. • determine the biological activity of drug substances with the aid of established in-vitro-assays and to evaluate the corresponding results. • develop and apply methods to quantify drug substances in biological matrices.
Type of module examination	Written or oral examination
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. D. Merk
Language(s) of instruction	German
Other information	Not specified

Module: P 5 Advances in pharmaceutical sciences

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Seminar	P 5.1 Current research results in pharmaceutical sciences, Advanced seminar I	WS and SS	30 h (2 SWS)	60 h	(3)
Seminar	P 5.2 Current research results in pharmaceutical sciences, Advanced seminar II	WS and SS	30 h (2 SWS)	60 h	(3)
Seminar	P 5.3 Current research results in pharmaceutical sciences, Advanced seminar III	WS and SS	30 h (2 SWS)	60 h	(3)

A total of 9 ECTS credit points must be acquired in the module. Compulsory attendance: 6 periods per week during the semester. Taking personal studies into account, around 270 hours are required.

Module type	Mandatory module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	None
Prerequisites for participation	None
Semester of degree course	Recommended semester: 2
Duration	This module lasts for 3 semester.
Contents	In this **module**, students are introduced to and discuss current interdisciplinary scientific questions relating to pharmaceutical drugs, and the latest results from departmental research and research in the surrounding world of science. In the **Advanced seminar I,** students select and attend scientific lectures from the *Current pharmaceutical sciences – talking to master students and PhD students* seminar, the *pharmaceutical colloquium* or other series of lectures, e.g., from the German Pharmaceutical Society, the Munich Chemistry Society, the Chemistry Department, the Gene Centre, the Biology Faculty, or the Max-Planck Institute. In the **Advanced seminars II** and **III**, students select and attend two work group seminars offered by the department. We recommend that the Advanced seminars II and III be completed in conjunction with an advanced laboratory placement and at the same time as writing your final master's thesis.

Qualification goals	On completion, students should be able to • outline and assess current questions and scientific approaches from the field of pharmaceutical research, placing these appropriately in a larger, interdisciplinary context. • develop research ideas autonomously. • research a topic by themselves, with the aid of scientific publications, and present their findings by giving a lecture or preparing a summarized, written review. • hold scientific discussions and share scientific insights, principles and findings not only with experts, but also with laypersons.
Type of module examination	Written or oral project report
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Academic dean
Language(s) of instruction	German or English
Other information	not specified

Module: WP 1 Advanced molecular pharmacology – Field A

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	WP 1.1 Advanced laboratory placement Molecular pharmacology, Field A	WS and SS	165 h (11 SWS)	165 h	(11)
Laboratory placement	WP 1.2 Molecular pharmacology, introduction to academic writing, Field A	WS and SS	15 h (1 SWS)	15 h	(1)

In this module, students must acquire a total of 12 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 360 hours are required.

Module type	Elective module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	The module can be selected subject to the following criteria: One elective module must be chosen from elective modules WP 1 to WP 4.
Prerequisites for participation	None
Semester of degree course	Recommended semester: 2
Duration	This module lasts for 1 semester.
Contents	The **elective module** involves working on a research project from the field of molecular and systemic pharmacology. Here, students are required to apply and thereby expand their existing theory and methodological skills to new or unfamiliar contexts/questions. Students practice working in a real, specific research environment. In the **advanced laboratory placement**, students can select a project which focuses on one of the following topics (selection): tests for function and pathophysiology in the following fields: • CNS • eyes • cardiovascular system Students are given in-depth insights into a wide selection of the most recent experimental methods used in molecular pharmacology: • molecular gene therapy methods, e.g., viral vectors which can be used in therapy • bioinformatic methods (including genome analysis)

	• biophysical methods (including patch clamp) • imaging (including FRET, Ca imaging) • methods for analyzing neuronal circuits In the integrated course lecture **Introduction to academic writing**, students build on existing knowledge and skills in the fields of laboratory techniques, literature research, and planning, conducting, evaluating, documenting, and interpreting scientific experiments.
Qualification goals	On completion, students should be able to • outline the current state of research in the sub-area of molecular pharmacology they have studied. • outline the repertoire of modern methodological approaches for explaining disease processes and defining new pharmaceutical drug targets, and select the appropriate approach for the current need. • research relevant literature for scientific questions. • plan, conduct, and evaluate scientific experiments (largely unsupervised), document these in accordance with the rules of "Good Scientific Practice", and interpret the results. • work on an interdisciplinary level and in a team. • structure and schedule a project. • justify the approach chosen for the project in question, present the results in a discussion with experts or by giving a seminar, and defend these results in debate.
Type of module examination	Written or oral examination or presentation
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. Martin Biel, Prof. Dr. Christian Wahl-Schott
Language(s) of instruction	German or English
Other information	not specified

Module: WP 2 Advanced pharmaceutical biology and biotechnology – Field A

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	WP 2.1 Advanced laboratory placement Pharmaceutical biology and biotechnology, Field A	WS and SS	165 h (11 SWS)	165 h	(11)
Laboratory placement	WP 2.2 Pharmaceutical biology and biotechnology, Introduction to academic writing, Field A	WS and SS	15 h (1 SWS)	15 h	(1)

In this module, students must acquire a total of 12 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 360 hours are required.

Module type	Elective module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	The module can be selected subject to the following criteria: One elective module must be chosen from elective modules WP 1 to WP 4.
Prerequisites for participation	None
Semester of degree course	Recommended semester: 2
Duration	This module lasts for 1 semester.
Contents	The **elective module** involves working in a team on a research project from the field of pharmaceutical biology and biotechnology. Here, students are required to apply and thereby expand their existing theory and methodological skills to new or unfamiliar contexts/questions. Students practice working in a real, specific research environment. In the **advanced laboratory placement**, students can select a project which focuses on one of the following topics (selection): • tumor biology • angiogenesis • tumor targeting • nucleic acid therapeutic agents • chemoresistance of tumors Students are given in-depth insights into a wide selection of the experimental methods currently used in pharmaceutical biology

	and biotechnology: • quantitative PCR • flow cytometry • advanced microscope techniques • silencing strategies, e.g., RNA interference • gene transfer, protein overexpression In the integrated course lecture **Introduction to academic writing**, students build on existing knowledge and skills in the fields of laboratory techniques, literature research, and planning, conducting, evaluating, documenting, and interpreting scientific experiments.
Qualification goals	On completion, students should be able to • outline the current state of research in the sub-area of biology and biotechnology they have studied. • outline the repertoire of modern methodological approaches for identifying and characterizing drug substance targets and for testing active substances, and select the appropriate approach for the current need. • research relevant literature for scientific questions. • plan, conduct, and evaluate scientific experiments (largely unsupervised), document these in accordance with the rules of "Good Scientific Practice", and interpret the results. • work on an interdisciplinary level and in a team. • structure and schedule a project. • design and present a scientific poster. • justify the approach chosen for the project in question, present the results in a discussion with experts or by giving a seminar, and defend these results in debate.
Type of module examination	Written or oral examination or presentation
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. Angelika Vollmar, Prof. Dr. Ernst Wagner
Language(s) of instruction	WP 2.1 German or English, WP 2.2 English
Other information	not specified

Module: WP 3 Advanced pharmaceutical technology and biopharmacy – Field A

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	WP 3.1 Advanced laboratory placement Advanced pharmaceutical technology and biopharmacy, Field A	WS and SS	165 h (11 SWS)	165 h	(11)
Laboratory placement	WP 3.2 Pharmaceutical technology and biopharmacy, Introduction to academic writing, Field A	WS and SS	15 h (1 SWS)	15 h	(1)

In this module, students must acquire a total of 12 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 360 hours are required.

Module type	Elective module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	The module can be selected subject to the following criteria: One elective module must be chosen from elective modules WP 1 to WP 4.
Prerequisites for participation	None
Semester of degree course	Recommended semester: 2
Duration	This module lasts for 1 semester.
Contents	The **elective module** involves working on a research project from the field of pharmaceutical technology and biopharmacy. Here, students are required to apply and thereby expand their existing theory and methodological skills to new or unfamiliar contexts / questions. Students practice working in a real, specific research environment. In the **advanced laboratory placement**, students can select a project which focuses on one of the following topics (selection): • protein formulation • drug delivery systems • nanoparticular systems – production and characterization Students are given in-depth insights into a wide selection of the experimental methods currently used in pharmaceutical technology and biopharmacy:

	• protein analysis, e.g., chromatographic methods or modern particle analysis • manufacturing techniques, in particular drying methods (including freeze-drying and spray drying) and particle production • characterization methods from physical chemistry, e.g., determining zeta potential, measuring the size of particles or thermal analysis procedures • drug release models In the integrated course lecture **Introduction to academic writing**, students build on existing knowledge and skills in the fields of laboratory techniques, literature research, and planning, conducting, evaluating, documenting, and interpreting scientific experiments.
Qualification goals	On completion, students should be able to • outline the current state of research in the sub-area of pharmaceutical technology and biopharmacy they have studied. • outline the repertoire of modern methodological approaches for manufacturing and analyzing pharmaceutical drugs, and select the appropriate approach for the current need. • research relevant literature for scientific questions. • plan, conduct, and evaluate scientific experiments (largely unsupervised), document these in accordance with the rules of "Good Scientific Practice", and interpret the results. • work on an interdisciplinary level and in a team. • structure and schedule a project. • justify the approach chosen for the project in question, present the results in a discussion with experts or by giving a seminar, and defend these results in debate.
Type of module examination	Written or oral examination or presentation
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. Wolfgang Frieß, Prof. Dr. Gerhard Winter
Language(s) of instruction	German or English
Other information	Not specified

Module: WP 4 Advanced medical chemistry and pharmaceutical analysis – Field A

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	WP 4.1 Advanced laboratory placement for medical chemistry and pharmaceutical analysis, Field A	WS and SS	165 h (11 SWS)	165 h	(11)
Laboratory placement	WP 4.2 Medical chemistry and pharmaceutical analysis, introduction to academic writing, Field A	WS and SS	15 h (1 SWS)	15 h	(1)

In this module, students must acquire a total of 12 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 360 hours are required.

Module type	Elective module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	The module can be selected subject to the following criteria: One elective module must be chosen from elective modules WP 1 to WP 4.
Prerequisites for participation	None
Semester of degree course	Recommended semester: 2
Duration	This module lasts for 1 semester.
Contents	The **elective module** involves working in a team on a research project from the field of medical chemistry and pharmaceutical analysis. Here, students are required to apply and thereby expand their existing theory and methodological skills to new or unfamiliar contexts/questions. Students practice working in a real, specific research environment. In the **advanced laboratory placement**, students can select a project which focuses on one of the following topics (selection): • synthesis of potential CNS drugs • development of structure-activity relationships • structure of chemical libraries • MS-based bioassays • analysis of active substances with GC-MS • synthesis of enzyme inhibitors

	• natural products chemistry Students are given in-depth insights into a wide selection of the latest experimental methods used in medical chemistry and pharmaceutical analysis: • modern synthesis methods, e.g., micro-scale synthesis, techniques for working with inert gas (the Schlenk line), transition metal-catalyzed coupling reaction or organometallic techniques in heterocycle synthesis, microwave-based syntheses • binding assays and transport assays • LC-MS analysis • pharmacokinetic characterization of drug substances • GC–MS analysis, including modern methods for preparing samples • cellular assays to characterize enzyme inhibitors In the integrated course lecture **Introduction to academic writing**, students build on existing knowledge and skills in the fields of laboratory techniques, literature research, and planning, conducting, evaluating, documenting, and interpreting scientific experiments.
Qualification goals	On completion, students should be able to • outline the current state of research in the sub-area of medical chemistry and pharmaceutical analysis they have studied. • outline the repertoire of modern methodological approaches for developing and characterizing bioactive compounds, and select the appropriate approach for the current need. • research relevant literature for scientific questions. • plan, conduct, and evaluate scientific experiments (largely unsupervised), document these in accordance with the rules of "Good Scientific Practice", and interpret the results. • work on an interdisciplinary level and in a team. • structure and schedule a project. • justify the approach chosen for the project in question, present the results in a discussion with experts or by giving a seminar, and defend these results in debate.
Type of module examination	Written or oral examination or presentation
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. F. Bracher, Prof. Dr. K. T. Wanner

Language(s) of instruction	German or English
Other information	Not specified

Module: P 6 Final module

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Master's thesis	P 6.1 / I Master's thesis	WS and SS	-	180 h	(6)
Master's thesis	P 6.1 / II Master's thesis	WS and SS	-	660 h	(22)
Oral exam	P 6.2 Oral exam	WS and SS	-	150 h	5

In this module, students must acquire a total of 33 ECTS credit points. Compulsory attendance: 0 periods per week during the semester. Taking personal studies into account, around 990 hours are required.

Module type	Mandatory module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	None
Prerequisites for participation	Successful completion of P 1 to P 4 and (WP 1 or WP 2 or WP 3 or WP 4) and (WP 5 or WP 6 or WP 7 or WP 8)
Semester of degree course	Recommended semester: 3
Duration	This module lasts for 2 semesters.
Contents	For their **master's thesis**, students work alone to write their own scientific dissertation on a topical issue from pharmaceutical science. The **final examination** consists of the master's thesis and the results of this. Students will be required to present the results of their research to a panel of experts, position their results in the wider context of pharmaceutical sciences (in particular, the specialized field of their master's thesis and one further field of study within their master's degree course), and discuss the results.
Qualification goals	On completion, students should be able to • work to a deadline to plan, without supervision, a scientific dissertation on a topical issue from pharmaceutical science, and to structure and write the dissertation according to "Good Scientific Practice" and accepted scientific conventions, using the knowledge

	and skills they have acquired. • research, evaluate, and critically assess relevant literature required for the topic. • make hypotheses to solve the respective scientific question, and test these by means of experiments. • plan, conduct, and evaluate scientific experiments (supervised), document these in accordance with the rules of "Good Scientific Practice", and interpret, question, and categorize the results in the context of published insights. • present the results of their master's thesis to a panel of experts, either by giving a lecture or in the form of a discussion, and to defend their position in debate.
Type of module examination	
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	The chairperson of the examination board
Language(s) of instruction	German or English
Other information	Not specified

Module: WP 5 Advanced molecular pharmacology – Field B

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	WP 5.1 Advanced laboratory placement Molecular pharmacology, Field B	WS and SS	300 h (20 SWS)	300 h	(20)
Laboratory placement	WP 5.2 Molecular pharmacology, introduction academic writing, Field B	WiSe und SoSe	15 h (1 SWS)	15 h	(1)

In this module, students must acquire a total of 21 ECTS credit points. Compulsory attendance: 21 periods per week during the semester. Taking personal studies into account, around 630 hours are required.

Module type	Elective module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	The module can be selected subject to the following criteria: One elective module must be chosen from elective modules WP 5 to WP 8.
Prerequisites for participation	Successful completion of P 2.1
Semester of degree course	Recommended semester: 3
Duration	This module lasts for 1 semester.
Contents	The **elective module** – in contrast to mandatory module WP 1 (see above) – includes more in-depth involvement on a research project from the field of molecular and systemic pharmacology. Here, students are required to apply and thereby expand their existing theory and methodological skills to new or unfamiliar contexts/questions. Students continue to practice working in a real, specific research environment. In the **advanced laboratory placement**, students can select a project which focuses on one of the following topics (selection): tests for function and pathophysiology in the following fields: • CNS • eyes • cardiovascular system Potentially, projects can be thematically linked to project work from WP 1. Students are given in-depth insights into a wide selection of the most recent experimental methods used in molecular

	pharmacology: • molecular gene therapy methods, e.g., viral vectors which can be used in therapy • bioinformatic methods (including genome analysis) • biophysical methods (including patch clamp) • imaging (including FRET, Ca imaging) • methods for analyzing neuronal circuits In the integrated course lecture **Introduction to academic writing**, students build on existing knowledge and skills in the fields of laboratory techniques, literature research, and planning, conducting, evaluating, documenting, and interpreting scientific experiments.
Qualification goals	On completion, students should be able to • outline the current state of research in the sub-area of molecular pharmacology they have studied. • outline the repertoire of modern methodological approaches for explaining disease processes and defining new pharmaceutical drug targets, and select the appropriate approach for the current need. • research relevant literature for scientific questions. • plan, conduct, and evaluate scientific experiments (largely unsupervised), document these in accordance with the rules of "Good Scientific Practice", and interpret the results. • work on an interdisciplinary level and in a team. • structure and schedule a project. • justify the approach chosen for the project in question, present the results in a discussion with experts or by giving a seminar, and defend these results in debate.
Type of module examination	Written or oral examination or presentation
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. Martin Biel, Prof. Dr. Christian Wahl-Schott
Language(s) of instruction	German or English
Other information	not specified

Module: WP 6 Advanced pharmaceutical biology and biotechnology – Field B

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	WP 6.1 Advanced laboratory placement Pharmaceutical biology and biotechnology, Field B	WS and SS	300 h (20 SWS)	300 h	(20)
Laboratory placement	WP 6.2 Pharmaceutical biology and biotechnology, Introduction to academic writing, Field B	WS and SS	15 h (1 SWS)	15 h	(1)

In this module, students must acquire a total of 21 ECTS credit points. Compulsory attendance: 21 periods per week during the semester. Taking personal studies into account, around 630 hours are required.

Module type	Elective module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	The module can be selected subject to the following criteria: One elective module must be chosen from elective modules WP 5 to WP 8.
Prerequisites for participation	Successful completion of P 2.1
Semester of degree course	Recommended semester: 3
Duration	This module lasts for 1 semester.
Contents	The **elective module** – in contrast to the elective module WP 2 (see above) – involves working in a team on a research project from the field of pharmaceutical biology and biotechnology. Here, students are required to apply and thereby expand their existing theory and methodological skills to new or unfamiliar contexts/questions. Students continue to practice working in a real, specific research environment. In the **advanced laboratory placement**, students can select a project which focuses on one of the following topics (selection): • tumor biology • angiogenesis • tumor targeting • nucleic acid therapeutic agents • chemoresistance of tumours Potentially, projects can be thematically linked to project work

	from WP 2. Students are given in-depth insights into a wide selection of the experimental methods currently used in pharmaceutical biology and biotechnology: • quantitative PCR • flow cytometry • advanced microscope techniques • silencing strategies, e.g., RNA interference • gene transfer, protein overexpression In the integrated course lecture **Introduction to academic writing**, students build on existing knowledge and skills in the fields of laboratory techniques, literature research, and planning, conducting, evaluating, documenting, and interpreting scientific experiments.
Qualification goals	On completion, students should be able to • outline the current state of research in the sub-area of biology and biotechnology they have studied. • outline the repertoire of modern methodological approaches for identifying and characterizing drug substance targets and for testing active substances, and select the appropriate approach for the current need. • research relevant literature for scientific questions. • plan, conduct, and evaluate scientific experiments (largely unsupervised), document these in accordance with the rules of "Good Scientific Practice", and interpret the results. • work on an interdisciplinary level and in a team. • structure and schedule a project. • design and present a scientific poster. • justify the approach chosen for the project in question, present the results in a discussion with experts or by giving a seminar, and defend these results in debate.
Type of module examination	Written or oral examination or presentation
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. Angelika Vollmar, Prof. Dr. Ernst Wagner
Language(s) of instruction	German or English
Other information	Not specified

Module: WP 7 Advanced pharmaceutical technology and biopharmacy – Field B

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	WP 7.1 Advanced laboratory placement Advanced pharmaceutical technology and biopharmacy, Field B	WS and SS	300 h (20 SWS)	300 h	(20)
Laboratory placement	WP 7.2 Pharmaceutical technology and biopharmacy, Introduction to academic writing, Field B	WS and SS	15 h (1 SWS)	15 h	(1)

In this module, students must acquire a total of 21 ECTS credit points. Compulsory attendance: 21 periods per week during the semester. Taking personal studies into account, around 630 hours are required.

Module type	Elective module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	The module can be selected subject to the following criteria: One elective module must be chosen from elective modules WP 5 to WP 8.
Prerequisites for participation	Successful completion of P 2.1
Semester of degree course	Recommended semester: 3
Duration	This module lasts for 1 semester.
Contents	The **elective module** – in contrast to mandatory module WP 3 (see above) – includes more in-depth involvement on a research project from the field of pharmaceutical technology and biopharmacy. Here, students are required to apply and thereby expand their existing theory and methodological skills to new or unfamiliar contexts/questions. Students continue to practice working in a real, specific research environment. In the **advanced laboratory placement**, students can select a project which focuses on one of the following topics (selection): • protein formulation • drug delivery systems • nanoparticular systems – production and characterization Potentially, projects can be thematically linked to project work from WP 3.

	Students are given in-depth insights into a wide selection of the experimental methods currently used in pharmaceutical technology and biopharmacy: • protein analysis, e.g., chromatographic methods or modern particle analysis • manufacturing techniques, in particular drying methods (including freeze-drying and spray drying) and particle production • characterization methods from physical chemistry, e.g., determining zeta potential, measuring the size of particles or thermal analysis procedures • drug release models In the integrated course lecture **Introduction to academic writing**, students build on existing knowledge and skills in the fields of laboratory techniques, literature research, and planning, conducting, evaluating, documenting, and interpreting scientific experiments.
Qualification goals	On completion, students should be able to • outline the current state of research in the sub-area of pharmaceutical technology and biopharmacy they have studied. • outline the repertoire of modern methodological approaches for manufacturing and analysing pharmaceutical drugs, and select the appropriate approach for the current need. • research relevant literature for scientific questions. • plan, conduct, and evaluate scientific experiments (largely unsupervised), document these in accordance with the rules of "Good Scientific Practice", and • interpret the results. • work on an interdisciplinary level and in a team. • structure and schedule a project. • justify the approach chosen for the project in question, present the results in a discussion with experts or by giving a seminar, and defend these results in debate.
Type of module examination	Written or oral examination or presentation
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS credit points	ECTS points will be credited once the student has passed the respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. Wolfgang Frieß, Prof. Dr. Gerhard Winter
Language(s) of instruction	German or English
Other information	Not specified

Module: WP 8 Advanced medical chemistry and pharmaceutical analysis – Field B

Assigned to degree	Master's degree: Pharmaceutical Sciences (Master of Science, M.Sc.)

Associated sub-modules

Course type	Event (compulsory)	Semester	Compulsory attendance	Self-study	ECTS
Laboratory placement	WP 8.1 Advanced laboratory placement for medical chemistry and pharmaceutical analysis, Field B	WS and SS	300 h (20 SWS)	300 h	(20)
Laboratory placement	WP 8.2 Medical chemistry and pharmaceutical analysis, introduction to academic writing, Field B	WS and SS	15 h (1 SWS)	15 h	(1)

In this module, students must acquire a total of 21 ECTS. Compulsory attendance: 21 periods per week during the semester. Taking personal studies into account, around 630 hours are required.

Module type	Elective module with compulsory attendance.
Applicability of the module for other degree courses	
Regulations for electives	The module can be selected subject to the following criteria: One elective module must be chosen from elective modules WP 5 to WP 8.
Prerequisites for participation	Successful completion of P 2.1
Semester of degree course	Recommended semester: 3
Duration	This module lasts for 1 semester.
Contents	The **elective module** – in contrast to the elective module WP 4 (see above) – involves working in a team on a research project from the field of medical chemistry and pharmaceutical analysis. Here, students are required to apply and thereby expand their existing theory and methodological skills to new or unfamiliar contexts/questions. Students continue to practice working in a real, specific research environment. In the **advanced laboratory placement**, students can select a project which focuses on one of the following topics (selection): • synthesis of potential CNS drugsEntwicklung von Struktur-Aktivitäts-Beziehungen • development of structure-activity relationships • structure of chemical libraries • MS-based bioassays • analysis of active substances with GC-MS

	• synthesis of enzyme inhibitors • natural products chemistry Potentially, projects can be thematically linked to project work from WP 4. Students are given in-depth insights into a wide selection of the latest experimental methods used in medical chemistry and pharmaceutical analysis: • modern synthesis methods, e.g., micro-scale synthesis, techniques for working with inert gas (the Schlenk line), transition metal-catalyzed coupling reaction or organometallic techniques in heterocycle synthesis, microwave-based syntheses • binding assays and transport assays • LC-MS analysis • pharmacokinetic characterization of drug substances • GC–MS analysis, including modern methods for preparing samples • cellular assays to characterize enzyme inhibitors In the integrated course lecture **Introduction to academic writing**, students build on existing knowledge and skills in the fields of laboratory techniques, literature research, and planning, conducting, evaluating, documenting, and interpreting scientific experiments.
Qualification goals	On completion, students should be able to • outline the current state of research in the sub-area of medical chemistry and pharmaceutical analysis they have studied. • outline the repertoire of modern methodological approaches for developing and characterizing bioactive compounds, and select the appropriate approach for the current need. • research relevant literature for scientific questions. • plan, conduct, and evaluate scientific experiments (largely unsupervised), document these in accordance with the rules of "Good Scientific Practice", and interpret the results. • work on an interdisciplinary level and in a team. • structure and schedule a project. • justify the approach chosen for the project in question, and present the results in a discussion with experts or by giving a seminar presentation, and to defend these results in debate.
Type of module examination	Written or oral examination or presentation
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS	ECTS points will be credited once the student has passed the

credit points	respective examination for the module in question (or the assigned compulsory or elective examination part).
Person responsible for the module	Prof. Dr. F. Bracher, Prof. Dr. K. T. Wanner
Language(s) of instruction	German or English
Other information	Not specified