LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Module Handbook

Bachelor's program: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

(180 ECTS credit points)

Based on the Examination & Study Regulations, dated March 18, 2016

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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
WP	Mandatory elective modules
M	Mandatory
ESR	Examination & Study Regulations

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 General and inorganic chemistry

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 1.1 General and inorganic chemistry (laboratory lectures)	WS	75 h (5 SWS)	105 h	(6)
Exercise	P 1.2 General and inorganic chemistry (practical exercises)	WS	45 h (3 SWS)	45 h	(3)
Laboratory course	P 1.3 General and inorganic chemistry (laboratory course)	WS	90 h (6 SWS)	30 h	(4)
Seminar	P 1.4 General and inorganic chemistry (accompanying seminar for laboratory course)	WS	15 h (1 SWS)	45 h	(2)

A total of 15 ECTS credit points must be acquired in the module. Compulsory attendance: 15 periods per week during the semester. Taking personal studies into account, around 450 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Standard semester: 1
Duration	This module lasts for 1 semester.
Contents	The **module** covers the theoretic and practical basics of general and inorganic chemistry. The **lectures** deal with the basic aspects of general and inorganic chemistry, in particular: Part A – Basics • The structure of matter • Atoms • Covalent bonds • Gas-phase reactions • Polar molecules • Ionic bonding • Chemical balances • Acid-base reactions • Redox reactions • Electrochemistry

- Solids

Part B – Chemistry of the elements

- Hydrogen
- Halogens (group 17)
- Noble gases (group 18)
- Chalcogens (group 16)
- Pnictogens (group 15)
- The carbon family (group 14)
- The boron family (group 13)
- Alkaline earth metals (group 2)
- Alkali metals (group 1)
- Metal extraction
- Transition metals (groups 3 to 12)

During the laboratory lectures and the laboratory course, students are also taught basic principles (theory and practice) for safety in the laboratory.

The content of the lectures is reinforced by **practical exercises,** which aim to explore the content in more detail.

During the **laboratory course**, students conduct experiments which relate to the themes covered by the lectures, and learn to handle and dispose of hazardous substances correctly:

- General laboratory equipment and work methods (dealing with safety equipment in the laboratory, handling and disposing of chemicals, including hazardous substances, using scales, centrifuges, Bunsen burners, pipettes, etc.; Heating solutions, (vacuum) filtration, centrifugation, crystallisation, spectroscopy)
- Acid-base concepts (properties, the Lewis theory and the Brønsted theory, the strengths of acids and bases, dissociation constants, amphoterism, pH values, buffers, the reaction behaviour of certain acids)
- Redox chemistry (pH dependency, oxidising agents, reducing agents, redox amphoterism, disproportionation, comproportionation, standard potential, electrochemical series)
- Complex chemistry (structure of complexes, ligands, complex geometry, ligand substitution, chelation, colour, stability of complexes)
- Chemical equilibrium (the effects of pH, temperature and concentration, shift in balance, solubility products)
- Experiments for qualitative inorganic analysis (practical applications for the concepts learned)

	In the corresponding **seminar**, the content of the laboratory course is followed up and conneceted to theoretical concepts of general and inorganic chemistry.
Qualification goals	On completion, students should be able to • describe and explain the basic laws, models and concepts of general and inorganic chemistry. • handle hazardous substances safely and dispose of them correctly, in accordance with the applicable guidelines and regulations. • use standard laboratory equipment (e.g., Bunsen burners, centrifuges and scales) and laboratory safety equipment (e.g., vents, emergency eye wash units, emergency showers). • correctly and safely use basic chemical work methods (e.g., pipetting, separating mixtures of substances via filtration, vacuum filtration, centrifugation, or extraction). • conduct, analyse, and record simple experiments in the field of inorganic chemistry. • question possible sources of error in experiment results, and interpret these in the light of the theoretical principles they have learned. • apply concepts from general and inorganic chemistry theory to questions relating to qualitative inorganic analytics.
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. I. Huc
Language(s) of instruction	German
Other information	

Module: P 2 Basic principles of biology

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 2.1 Basic principles of biology (lecture)	WS	45 h (3 SWS)	75 h	(4)
Exercise	P 2.2 Basic principles of biology (practical exercises)	WS	15 h (1 SWS)	45 h	(2)
Laboratory course	P 2.3 Basic principles of biology (laboratory course)	WS	60 h (4 SWS)	60 h	(4)
Seminar	P 2.4 Basic principles of biology (accompanying seminar for laboratory course)	WS	15 h (1 SWS)	45 h	(2)

In this module, students must acquire a total of 12 ECTS credit points. Compulsory attendance: 9 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Standard semester: 1
Duration	This module lasts for 1 semester.
Contents	The **module** covers the basic theoretical and practical principles of biology relevant to pharmaceutical sciences. The **lectures** deal with the basic concepts of biology. Amongst other things, these include: • the structure of prokaryotic and eukaryotic organisms • genetic information and heredity • the structural and chemical components of cells • energy metabolism • cellular communication • transport phenomena The accompanying **practical exercises** explore the content of the lectures in more detail. In the **laboratory course**, students learn and practice basic techniques of biological laboratory practice. These include, for example, pipetting small volumes,

	determining protein content, cultivating bacteria, and microscopy. Basic theory is discussed in the accompanying **seminar.** Here, students also learn to analyze the results of experiments and record these in the form of protocols.
Qualification goals	On completion, students should be able to • describe and explain the basic laws, models and concepts of biology, and apply these to basic pharmaceutical questions. • find and assess sources for biological information and acquire new knowledge autonomously. • conduct simple biological experiments (with supervision). • analyze, present, and discuss the results of experiments.
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. S. Zahler
Language(s) of instruction	German
Other information	

Module: P 3 Basic principles of physics and physical chemistry

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 3.1 Physics (lecture)	WS	30 h (2 SWS)	30 h	(2)
Exercise	P 3.2 Physics (practical exercises)	WS	15 h (1 SWS)	15 h	(1)
Laboratory course	P 3.3 Physics and physical chemistry laboratory course	SS	45 h (3 SWS)	15 h	(2)
Lecture	P 3.4 Physical chemistry for pharmacists	SS	30 h (2 SWS)	60 h	(3)
Exercise	P 3.5 Mathematics and statistics	SS	15 h (1 SWS)	15 h	(1)

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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Standard semester: 1 and 2
Duration	This module lasts for 2 semesters.
Contents	The **module** covers the basic theoretical and practical principles of physics and physical chemistry, and the basic areas of mathematics and statistics used in pharmaceutical sciences. In the ***physics*** **lectures**, students are taught basic aspects of physics. Amongst other things, these include: • mechanics • wavelength theory • electromagnetism • optics • thermodynamics • nuclear physics, radiation, and radiation protection The accompanying **practical exercises** explore the content of the lectures in more detail.

	In the *physical chemistry* lectures, students learn about basic aspects of physical chemistry, including amongst other things the following topics: • the state of matter • phases / phase equilibrium • thermodynamics • chemical equilibrium • reaction kinetics • electrochemistry • spectroscopy During the laboratory course, students conduct experiments which relate to the themes covered by the lectures. In the practical exercises for *Mathematics and statistics*, students revise basic aspects of mathematics and statistics, and go into these in more detail: • basic mathematics, including elementary functions, differentiation, integration, and linear algebra • probability theory • statistical test procedures
Qualification goals	On completion, students should be able to • describe and explain the basic laws, models, and concepts of physics and physical chemistry, and apply these to basic pharmaceutical questions. • formulate, solve, and interpret the results of elementary questions in the field of physics and physical chemistry with the aid of mathematical equations. • conduct experiments in the fields of physics and physical chemistry and interpret the results, also with regard to possible uncertainty and reproducibility. • solve statistical problems and select and apply suitable statistical test procedures.
Type of module examination	Written 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	Dean of studies
Language(s) of instruction	German
Other information	

Module: P 4 Quantitative inorganic analysis

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Seminar	P 4.1 Quantitative inorganic analysis (seminar)	SS	15 h (1 SWS)	45 h	(2)
Seminar	P 4.2 Stoichiometry	SS	15 h (1 SWS)	45 h	(2)
Seminar	P 4.3 Electrochemical methods	SS	15 h (1 SWS)	45 h	(2)
Laboratory course	P 4.4 Quantitative inorganic analysis (laboratory course)	SS	90 h (6 SWS)	0 h	(3)

A total of 9 ECTS 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Standard semester: 2
Duration	This module lasts for 1 semester.
Contents	The **module** covers the basic theoretical and practical principles of quantitative inorganic analysis, including electrochemical methods. In the **seminars**, students are taught the basic concepts and methods of quantitative inorganic analysis and electrochemical analysis: • methods and principles of quantitative analysis, including equipment methodology • methods for volumetric analysis (precipitation titration, acid-base titration, complex formation titration, and redox titration with indication methods) • basic principles and work methods for electrochemical analyses (calculating titration curves, evaluating data, calibration, and error analysis) • stoichiometric calculations • pharmacopoeia analyses for inorganic compounds

	In their **laboratory course**, students learn to conduct quantitative inorganic analyses on the basis of written instructions, including evaluation and documentation: • precipitation titration, acid-base titration, complex formation titration, and redox titration • atomic absorption spectroscopy • potentiometry, bivoltametry, conductometry, dead-stop titration, Karl Fischer titration
Qualification goals	On completion, students should be able to • explain the basic principles of analytic chemistry, electrochemistry, and atomic absorption spectroscopy. • apply laboratory techniques for quantitative inorganic analysis appropriately and without supervision. • make stoichiometric calculations. • independently select and apply evaluation, calibration, and validation methods within the given field; analyse errors and evaluate results. • document analytical-chemical experiments in the form of scientific protocols.
Type of module examination	Written or oral examination, laboratory course 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	Prof. Dr. I. Huc
Language(s) of instruction	German, English
Other information	

Module: P 5 Basic principles of organic chemistry

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 5.1 Basic principles of organic chemistry (laboratory lectures)	SS	75 h (5 SWS)	105 h	(6)
Exercise	P 5.2 Basic principles of organic chemistry (practical exercises)	SS	15 h (1 SWS)	15 h	(1)
Seminar	P 5.3 Nomenclature	SS	15 h (1 SWS)	15 h	(1)
Laboratory course	P 5.4 Introduction to the methods of organic synthesis	SS	75 h (5 SWS)	45 h	(4)

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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Standard semester: 2
Duration	This module lasts for 1 semester.
Contents	The **module** covers the basic theoretical and practicalprinciples of organic chemistry. In the **lectures**, students are introduced to the basic concepts and methods of organic chemistry: • compound theories, including the valence bond theory, hybridization, resonance, molecular orbital theory • Introduction to the primary types of reactions and mechanisms, including radical substitution reactions, SN1 and SN2 reactions, additions to C=C-double and C≡C-triple bonds, ß-elimination, substitution reactions on aromatic compounds, substitution reactions on carboxyl groups, addition of H nucleophiles, organometallic compounds and heteroatom nucleophiles to carbonyl compounds, condensation reactions, reactions of enols and enolates • overview of the primary functional groups and

compound classes (including alkanes, alkenes, alkines, aromatic compounds, and heteroaromatic compounds, halogenated hydrocarbons, alcohols, ethers, thioalcohols, and ethers, amines, organometallic compounds, aldehydes and ketones, carboxylic acids and derivatives, carbon dioxide derivatives), their physical properties, typical reactions, mutations, and syntheses
- introduction to stereochemistry
- overview of the primary synthetic polymers and classes of natural compounds (carbohydrates, amino acids and peptides, nucleic acids, isoprenoids)

The accompanying **practical exercises** explore the content of the lectures in more detail.

The **seminar** introduces students to the basics of systematic nomenclature for organic compounds according to IUPAC, as well as common retained names. Topics include:

- nomenclatures other than IUPAC
- nomenclature systems within the IUPAC nomenclature
- nomenclatures for saturated, unsaturated, branched acyclic, monocyclic, bridged, spirocyclic, and aromatic hydrocarbons
- nomenclature for unsaturated polycyclic hydrocarbons
- names for heterocycles with retained names, Hantzsch-Widman, and substitute nomenclature
- using functional groups as suffixes and prefixes

In the **laboratory course**, students conduct simple organic syntheses taken from academic literature. In doing so, they learn basic work methods for preparative organic chemistry, e.g., isolating products by precipitation or liquid / liquid extractions and product purification via fractionated distillation, recrystallisation, or column chromatography. Students learn to safely handle organic reagents and chemical apparatus, taking safety and environmental regulations into account.

Qualification goals

On completion, students should be able to

- demonstrate basic models and concepts for chemical bonds in organic molecules, and apply these to structural questions.
- outline the primary functional groups and classes of compounds in organic chemistry and their properties, and gauge typical reactions.
- outline the basic syntheses and transformations in the primary organic classes of compounds, and describe these using conventional scientific terminology.

	• formulate, explain, and interpret elementary organic reactions. • name organic compounds according to IUPAC rules. • synthesize, isolate, and purify simple organic compounds taken from academic literature, and document the results in a laboratory journal in accordance with the rules of good scientific practice. • handle hazardous substances and simple chemical apparatus responsibly and safely, taking safety and environmental regulations 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. D. Merk
Language(s) of instruction	German, English
Other information	

Module: P 6 Anatomy and physiology

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 6.1 Basic principles of anatomy and physiology 1	SS	45 h (3 SWS)	45 h	(3)
Lecture	P 6.2 Basic principles of anatomy and physiology 2	WS	45 h (3 SWS)	45 h	(3)
Laboratory course	P 6.3 Physiology and anatomy (laboratory course)	WS	45 h (3 SWS)	45 h	(3)

A total of 9 ECTS 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 2 and 3
Duration	This module lasts for 2 semesters.
Contents	The **module** covers the basic principles of physiology and anatomy. In the **lectures,** students are introduced to the molecular, cellular and systemic principles of organ and neurophysiology. They also gain insights into the clinical aspects of physiology and anatomy. In particular, students learn about the physiological principles and anatomical content required to understand pharmacology. The lectures focus on the following topics: Part 1 • receptor physiology and signal transduction • cardiac physiology • vascular physiology • physiology of the kidney • sensory systems • physiology of the respiratory system Part 2 • gastrointestinal physiology • neuroanatomy

	• motor systems • cellular neurophysiology • synaptic transmission • autonomic nervous system • physiology of muscle contractions • vascular physiology • blood and homeostasis • hormones In the **laboratory course**, students conduct basic physiological experiments. The laboratory course focuses on the following topics: • blood and haemostasis • neurophysiology • cardiac physiology (ECG tests) • vascular physiology (measuring blood pressure) • lung physiology (spirometric experiments and lung function tests with digital pneumotachograph) • physiology of the kidney • sensory physiology • anatomy (anatomage table)
Qualification goals	On completion, students should be able to • understand and describe the basic principles of the anatomy and physiology of the major organ systems. • explain basic aspects of physiology and anatomy on a molecular level, a cellular level, and on the level of tissues and organs. • describe the complex interaction between organ systems. • describe how physiological control systems work. • plan, conduct, evaluate, and interpret physiological experiments.
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. S. Koch
Language(s) of instruction	German
Other information	

Module: P 7 Integrated organic chemistry

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 7.1 Advanced organic chemistry	WS	45 h (3 SWS)	75 h	(4)
Seminar	P 7.2 Stereochemistry	WS	15 h (1 SWS)	15 h	(1)
Seminar	P 7.3 Synthesis and analytics of organic compounds (seminar)	WS	15 h (1 SWS)	15 h	(1)
Laboratory course	P 7.4 Synthesis and analytics of organic compounds (laboratory course)	WS	105 h (7 SWS)	75 h	(6)

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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 3
Duration	This module lasts for 1 semester.

Contents	In this **module,** students are introduced to advanced methods and concepts in organic chemistry.
	
	In the **lectures**, which follow on from the P 5.2 introductory lectures, the following topics are covered (selection):
	• reaction mechanisms
	• acidity and basicity of organic molecules
	• structure, properties, synthesis, and (bio)reactivity of heterocycles:
	  ○ non-aromatic heterocycles
	  ○ pyridine, chinoline, and isochinoline
	  ○ diazine, including annelated systems
	  ○ pyrrole and indole
	  ○ furan and thiophene
	  ○ pyrrazole and imidazole
	  ○ oxazole, isoxazole, thiazole, and isothiazole
	  ○ purine and pteridine
	• peptide synthesis
	  ○ amino acids and peptides

  - protective groups and coupling agents
  - solid phase synthesis
- modern methods of drug synthesis: including transition metal-catalyzed coupling reactions

In the **seminar**, students learn the basic principles of stereoisomerism in organic-chemical compounds, in particular for pharmaceutically relevant classes of compounds. Topics include:

- graphic depiction of stereoformula and descriptors for stereoisomer nomenclature
- classification of isomers and stereoisomers and the description of their respective properties
- symmetry properties
- stereoisomerism on the basis of different chiral elements (one stereogenic centre, two or more stereogenic centres, chiral axes and levels, helix structures)
- torsional isomerism
- prochirality
- targeted extraction of stereoisomers

During their **laboratory course**, students learn advanced work techniques and methods for organic synthesis, e.g., reaction monitoring/control with DC, UV, and IR spectroscopy, working under the exclusion of moisture and using inert gas technology, multi-level synthesis (including heterocycles) taken from academic literature.

In the **seminar** accompanying the laboratory course, students go into the methods and strategies of organic synthesis in more depth. Students practice designing simple multi-level synthesis.

Qualification goals

Students should be able to

- interpret reaction mechanisms based on reaction processes, and solve basic questions and problems relating to the chemoselectivity, regioselectivity, and stereoselectivity of organic reactions.
- list selected heterocycle classes, including their primary syntheses and transformations, and appraise their typical characteristics and (bio)reactivity.
- recognize acid and base substructures in organic molecules, and estimate their strength.
- explain modern methods of drug synthesis and describe such using conventional formulas.
- identify and describe the spatial design of molecules.
- portray stereoisomers graphically and name them using IUPAC nomenclature.

	• apply the basic principles of stereochemistry to new, unfamiliar structures. • confidently use advanced work methods for organic synthesis, including various methods for reaction monitoring/control. • conduct multi-level organic synthesis taken from academic literature, taking safety and environmental regulations into account. • design multi-level synthesis processes for organic molecules.
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. D. Merk
Language(s) of instruction	German, English
Other information	

Module: P 8 Instrumental organic analysis

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 8.1 Instrumental analysis	WS	45 h (3 SWS)	45 h	(3)
Seminar	P 8.2 Chemical structure	SS	45 h (3 SWS)	45 h	(3)
Laboratory course	P 8.3 Spectroscopic and chromatographic methods of analysis	SS	60 h (4 SWS)	30 h	(3)

A total of 9 ECTS must be acquired in the module. Compulsory attendance: 10 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 3 and 4
Duration	This module lasts for 2 semesters.
Contents	The **module** covers the basic theoretical and practical principles of instrumental organic analysis. In the **lectures**, students are introduced to the basic concepts and methods of instrumental analysis: • sampling and sample preparation • basic physical/chemical principles of optic and spectroscopic procedures (electromagnetic radiation, important spectral ranges, and the graphic depiction of spectra). • introduction to the most important optical and chiroptical procedures (refractometry, polarimetry, and circular dichroism) • basic principles of atom spectroscopy (atom absorption spectroscopy, flame photometry) • basic principles of molecular spectroscopy (UV/Vis, fluorescence, Raman and IR spectroscopy) • basic principles of NMR spectroscopy • basic principles of mass spectrometry • introduction to the principles of chromatographic separation (chromatographic separation mechanisms, phases, and parameters)

	• overview of the most important chromatographic procedures (PC, DC, LC, GC, SEC). • overview of the most common capillary electrophoretic processes • basics of radiochemical analysis In the **seminar**, students learn more about the basic principles of NMR spectroscopy and mass spectrometry and how to apply these when analysing the chemical structures of complex organic compounds. This is done by evaluating IR spectra and mass spectra in combination with one and two-dimensional NMR spectra. The NMR spectra portfolio for chemical structures includes the following: • ^{1}H–NMR spectra; 1D–NOE, ^{13}C, and DEPT spectra • H, H-COSY, HMQC, and HMBC spectra • ROESY and NOESY spectra. In the **laboratory course**, students are taught to use important equipment used in modern chemical analysis (including HPLC with various detection methods). Students learn how to solve organic analysis problems using instrumental methods, alone or in project groups. In doing so, they practice preparing samples, selecting suitable testing parameters, and evaluating and interpreting results.
Qualification goals	On completion, students should be able to • apply important spectroscopic and chromatographic analysis methods appropriately to issues concerning pharmaceutical analysis. • prepare samples appropriately and confidently deploy modern analysis instruments, including control and evaluation software. • evaluate chromatograms, spectra, and other measuring data, and interpret the results critically. • work in a team. • document the results obtained in form of scientific reports. • explain the structure of organic molecules, such as the use of drugs or simple natural products, and explain their strategy for finding results in oral presentations by using one- and two-dimensional NMR spectra, IR, UV/Vis, and mass spectra.
Type of module examination	Written examination and laboratory course 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	Prof. Dr. I. Huc, Dr. L. Allmendinger, Dr. C. Müller

Language(s) of instruction	German

Other information

Module: P 9 Basic principles of pharmaceutical technology, types of pharmaceutical drug, methods for manufacture and testing

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 9.1 Basic principles of pharmaceutical technology (lecture)	WS	30 h (2 SWS)	60 h	(3)
Laboratory course	P 9.2 Basic principles of pharmaceutical technology (Laboratory course)	WS	60 h (4 SWS)	30 h	(3)

In this module, students must acquire a total of 6 ECTS credit points. Compulsory attendance: 6 periods per week during the semester. Taking personal studies into account, around 180 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 3
Duration	This module lasts for 1 semester.
Contents	In this **module**, students learn the basics of pharmaceutical drug manufacture based on numerous practical examples. These include: • the primary types of pharmaceutical drugs, in particular their definition in accordance with the European Pharmacopoeia • basic galenic operations such as dispensing, crushing, mixing, sieving, emulgating, suspending, granulating, drying • small-scale documentation of the manufacturing process • quality requirements, in particular those dictated by the European Pharmacopoeia, including practical tests • the properties of excipients, using such appropriately in order to manufacture or stabilise

	specific types of dosage forms or to ensure such are effective and user-friendly
Qualification goals	On completion, students should be able to • explain the basic operations involved in pharmaceutical engineering and apply these to practical situations. • recognize, select, evaluate, and handle appropriate excipients for manufacturing pharmaceutical drugs depending on the specific pharmaceutical need. • describe and explain all relevant types of dosage forms, including the respective quality requirements. • take first steps in developing types of dosage forms, without supervision. • plan, conduct, and document simple manufacturing processes.
Type of module examination	Written (or oral examination) and laboratory course 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	Prof. Dr. W. Frieß, Prof. Dr. O. Merkel, Dr. A. Mößlang
Language(s) of instruction	German
Other information	

Module: P 10 Biochemistry, molecular biology and molecular medicine

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 10.1 Biochemistry and molecular biology	WS	45 h (3 SWS)	45 h	(3)
Lecture	P 10.2 Biochemistry and molecular medicine	SS	45 h (3 SWS)	105 h	(5)
Laboratory course	P 10.3 Biochemical methods and methods for molecular biology	SS	90 h (6 SWS)	90 h	(6)
Seminar	P 10.4 Seminar for laboratory course on methods for biochemical and molecular biology	SS	15 h (1 SWS)	15 h	(1)

A total of 15 ECTS must be acquired in the module. Compulsory attendance: 13 periods per week during the semester. Taking personal studies into account, around 450 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 3 and 4
Duration	This module lasts for 2 semesters.
Contents	The **module** covers the basic theoretical and practical principles of biochemistry, molecular biology, and molecular medicine. Both **lectures** cover the basic concepts and methods for biochemistry and molecular biology. The ***Biochemistry and molecular biology*** **lecture** covers: • the molecular structures of life (introduction to biochemistry) • the molecular dynamics of cells (from genomes to proteins, cell cycles and cell division, DNA replication, RNA transcription and processing, RNA interference, translation into proteins, modifications) • the metabolism of cells and organisms

(metabolism of carbohydrates, lipids, citric acid cycle and the respiratory chain, metabolism of nitrogen, amino acids, and nucleotides)
- introduction to molecular biology and genetic engineering (cloning, gene banks, sequencing, PCR, reporter genes, transfection, gene silencing with interference RNA, gene knock-out, transgenic animals, recombinant proteins)
- viruses (structure and infection process, based on selected examples)

The *Biochemistry and Molecular Medicine* lecture covers:

- gene defects, hereditary diseases, and somatic gene therapy
- genomics (the human genome, pharmacogenetics and pharmacogenomics, microarrays, SNP chips, expression profiling, data mining)
- proteomics (protein microarrays, 2D gel electrophoresis, mass spectrometric methods, determining protein-protein interaction, yeast two-hybrid, SELDI, quantitative proteomic analysis via SILAC) using practical, published examples (e.g., cancer research).
- molecular medicine (pathobiochemistry and the individuality of the human genome; SNP and CNV polymorphisms; genomes and cancer; functional genomics based on selected examples (e.g., chemoresistance with cancer)

In the laboratory course, students pass through three stages in which they learn to apply basic methods for biochemistry and molecular biology by conducting the following practical tests:

- immunological and electrophoretic analysis of blood protein (plasma centrifugation, native disc electrophoresis), electrophoretic fractionation of dialysed blood plasma, fractionation and colouring gels with Coomassie blue, colouring on lactate dehydrogenase activity, SDS polyacrylamide electrophoresis with ensuing silver colouring of the proteins, western blot with protein transfer and immune detection, ELISA)
- enzymatic tests (enzyme characterization, using lactate dehydrogenase, protein dependency, pH optimum, Michaelis-Menten characteristics Km and Vmax, inhibitor constants; enzyme purification using liver Glutathion-S transferase, raw enzyme extract, ammonium sulphate precipitation, desalination, affinity chromatography, drawing up a purification table, determining specific activity; biosynthesis of urea in the liver, production of a raw enzyme extract from a pig's liver, in vitro

	evidence of individual enzymes in the urea cycle; determining the enzymatic content of glucose, fructose, and cholesterol in analysis solutions) • molecular biology (production of competent E. coli cells, transformation of E. coli, preparation of recombinant plasmid DNA, determining UV concentration in plasmid DNA, restriction analysis of plasmid DNA, fractionation of restriction fragments via gel electrophoresis; preparation of human DNA, amplification of a DNA segment via PCR) In the accompanying **seminar,** students learn the basic theory behind the methods introduced in the laboratory course. Furthermore, the proliferation and migration of cultured tumour cells are evaluated and visualised via an online data cloud platform with AI-based analysis using a cell watcher.
Qualification goals	On completion, students should be able to • outline the basic biochemical structures and processes of a cell and an organism. • describe the basic concepts of molecular biology and molecular medicine. • outline biochemical methods for analysing and characterising biomolecules, and apply these practically. • deploy methods for molecular biology with recombinant or human DNA. • evaluate and protocol practical tests and results appropriately. • be able to handle recombinant and natural organic materials, hazardous substances and biochemical apparatus responsibly and safely, taking safety and environmental regulations into account.
Type of module examination	Written 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. E. Wagner
Language(s) of instruction	German
Other information	

Module: P 11 Basics of immunology and recombinant drug substances

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 11.1 Basic principles of immunology	SS	30 h (2 SWS)	60 h	(3)
Lecture	P 11.2 Recombinant drug substances	WS	30 h (2 SWS)	60 h	(3)
Seminar	P 11.3 Methods in Life Sciences	WS	30 h (2 SWS)	60 h	(3)

A total of 9 ECTS must be acquired in the module. Compulsory attendance: 8 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 4 and 5
Duration	This module lasts for 2 semesters.
Contents	The **module** covers the basic theoretical principles of immunology and immunopathology, as well as the basic principles of recombinant drug substances. The ***Basic principles of immunology*** **lecture** covers: • characteristics of congenital immune responses • characteristics of acquired immune responses • essential pathogens and their corresponding immune responses • Immunopathology: especially hypersensitivity reactions, immunotolerance and autoimmunity Firstly, the **lectures** on ***recombinant drug substances*** explain the principles of manufacturing this class of substances and provide an insight into a selected spectrum of therapeutically relevant biologics (especially with immunological effects): • Vaccines • Oncology and immuno-oncology

	• Cytokines and hormones • Insulins and glutides In the **seminar,** students learn basic techniques of modern biomedical disciplines with a special emphasis on drug- and target identification.
Qualification goals	On completion, students should be able to • outline the basic structure and functions of the immune system. • describe the essential features of immunopathology. • evaluate the manufacture and main features of recombinant drug substances, and find examples to illustrate these. • to explain the main therapeutic principles used by biologics, • gain and integrate new insights and knowledge on their own, and share such insights with experts and laymen in a manner that is easily comprehensible.
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. R. Fürst, Dr. S. Zahler
Language(s) of instruction	German
Other information	

Module: P 12 Medical chemistry and analysis of active substances

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 12.1 Medical chemistry 1	SS	45 h (3 SWS)	45 h	(3)
Lecture	P 12.2 Medical chemistry 2	WS	45 h (3 SWS)	105 h	(5)
Seminar	P 12.3 Analysis of active substances – HPLC method development and validation	WS	30 h (2 SWS)	30 h	(2)
Laboratory course	P 12.4 Analysis of active substances	WS	105 h (7 SWS)	45 h	(5)

A total of 15 ECTS must be acquired in the module. Compulsory attendance: 15 periods per week during the semester. Taking personal studies into account, around 450 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 4 and 5
Duration	This module lasts for 2 semesters.
Contents	The **module** covers the basic principles of medical chemistry and the analysis of active substances. In the ***Medical Chemistry 1*** **lecture**, basic medical-chemical questions are discussed for the following classes of active substances (selection): • vitamins • CNS agents In the ***Medical Chemistry 2*** **lecture**, basic medical-chemical questions are discussed for the following classes of active substances (selection): • hormones and drug substances which target hormone-dependent organs/tissues • therapy for hormone-sensitive tumours • cytostatic agents • anti-infectives In the **lectures**, students learn about: • the structures, structure-activity relationships, and

molecular mechanisms of action of drug substances from selected classes of drug substances.
- the chemistry of these drug substances (synthesis, stability, bioreactivity, analytics).
- biofunction of vitamins
- basic concepts for developing drug substances
- basic thermodynamic observations (energetic aspects) of ligand-target interaction
- the special features of pharmacopoeia analysis

In the **seminar** accompanying the laboratory course, students learn the basic principles of HPLC method development, basic statistical principles of data evaluation and characterisation of analytical methods and basic principles for validating analytical methods.

Topics include:

- Characterisation and targeted influencing/control of chromatographic parameters (such as R_s, k, A_s, N, etc.)
- validation parameters (specificity, correctness, precision, linearity, work area, durability, etc.) in accordance with the ICHQ2R2 guideline
- Calculation and interpretation of descriptive statistics and interference statistics
- Data evaluation with Excel, Prism and R
- practical examples (speakers from industry)

In the **laboratory course**, students form small project groups (2-3 students per HPLC unit) to learn HPLC methods for analysing and validating drug substances and documenting the results. In doing so, they use HPLC to analyse impurities and breakdown products from a self-synthesised drug substance (see laboratory course for *Synthesis and analysis of organic compounds* P 7.4). Further, students develop an HPLC method to determine the content of a drug substance in a finished pharmaceutical drug, and validate this following the ICHQ2R2 guideline.

Qualification goals

On completion, students should be able to

- detail the structures of drug substances from basic classes of drug substances, and demonstrate their structure-activity relationships, and molecular modes of action.
- outline the synthesis, stability, and analysis of selected drug substances.
- explain the biofunction of vitamins.
- describe basic concepts for developing drug substances.
- assess basic thermodynamic factors (energetic aspects) of target-ligand interaction.

	• outline the special features of pharmacopoeia analysis. • use existing knowledge to assess prescribed HPLC methods, implement these and develop their own methods. • outline basic statistical correlations in quantitative analysis. • define validation parameters from relevant guidelines (ICHQ2R2), describe these correctly and mathematically, and evaluate results from tests. • document in a scientifically correct manner the results of analytical HPLC specifications, including the corresponding method validation. • evaluate and discuss validation strategies used in the pharmaceutical industry in the field of HPLY analysis. • conduct application-based projects without supervision, in a team.
Type of module examination	Written (or oral examination) and scientific protocol
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. D. Merk
Language(s) of instruction	German, English
Other information	

Module: P 13 Pharmaceutical technology

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	13.1 Pharmaceutical technology 1	SS	30 h (2 SWS)	60 h	(3)
Lecture	13.2 Pharmaceutical technology 2	WS	30 h (2 SWS)	60 h	(3)

In this module, students must acquire a total of 6 ECTS. Compulsory attendance: 4 periods per week during the semester. Taking personal studies into account, around 180 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 4 and 5
Duration	This module lasts for 2 semesters.
Contents	The **module** covers the basic principles of pharmaceutical technology. In the lectures, students learn about basic aspects of solid and dispersed pharmaceutical drugs. This is taught in the context of industrial pharmaceutical drug manufacture. Amongst other things, the module covers physical-chemical basics (physical pharmacy) and special features of apparatus (pharmaceutical engineering) in the manufacture of various types of pharmaceutical drugs. In this connection, students are introduced to modern test methods for the characterisation of various types of pharmaceutical drugs, as well as raw materials and intermediate products. Students also learn in more depth about the use of auxiliary agents and advanced concepts for manufacturing and quality (GMP).
Qualification goals	On completion, students should be able to • understand and assess complex correlations in the development, manufacture and testing of various types of pharmaceutical drugs. • explain the selection of auxiliary agents and the manufacturing process for various types of pharmaceutical drugs, and assess these.

	• develop concepts for manufacturing pharmaceutical drugs. • make science-based decisions in the field of manufacturing pharmaceutical drugs. • professionally discuss information, ideas and problems relating to various types of pharmaceutical drugs with both experts and laymen.
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. W. Frieß, Prof. Dr. O. Merkel
Language(s) of instruction	German
Other information	

Module: WP 1 Research internship – Medical/pharmaceutical chemistry

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Laboratory course	WP 1.1 / I Modern methods of medical /pharmaceutical chemistry	SS	90 h (6 SWS)	0 h	(3)
Laboratory course	WP 1.1 / II Modern methods of medical /pharmaceutical chemistry	WS	90 h (6 SWS)	0 h	(3)

In this module, students must acquire a total of 6 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 180 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	Successful completion of P 5 and regular attendance at P 7.4
Semester of degree course	Recommended semester: 4 and 5
Duration	This module lasts for 2 semesters.
Contents	In the **elective module**, students gain first insights into pharmaceutical research. Under supervision, they work according to scientific aspects on closely defined projects which are relevant to actual current research, in the fields of medical chemistry / pharmaceutical analysis. Students learn in more depth about the theory and about basic methodological skills and work methods in the field of medical chemistry / pharmaceutical analysis. Under supervision, students develop their own projects within prescribed research fields.
Qualification goals	On completion, students should be able to • understand the theoretical and methodological context of the project at hand, and to autonomously acquire new knowledge and skills in the respective area of research.

	• apply familiar methods and work methods from medical chemistry and pharmaceutical analysis to new questions. • research relevant literature for the project at hand (supervised). • plan, conduct, evaluate, and document scientific experiments (supervised), and to interpret the results. • work in a team. • structure and schedule a project.
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	Prof. Dr. I. Huc, Prof. Dr. D. Merk
Language(s) of instruction	German or English
Other information	

Module: WP 2 Research internship – Pharmaceutical biology and biotechnology

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Laboratory course	WP 2.1 / I Modern methods of pharmaceutical biology and biotechnology	SS	90 h (6 SWS)	0 h	(3)
Laboratory course	WP 2.1 / II Modern methods of pharmaceutical biology and biotechnology	WS	90 h (6 SWS)	0 h	(3)

In this module, students must acquire a total of 6 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 180 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	Successful completion of P 2
Semester of degree course	Recommended semester: 4 and 5
Duration	This module lasts for 2 semesters.
Contents	In the **elective module**, students gain first insights into pharmaceutical research. Under supervision, they work scientifically on closely defined projects which are relevant to topical research in the fields of pharmaceutical biology and biotechnology. Students learn advanced theory and basic methodological skills and work methods in the field of pharmaceutical biology and biotechnology. Under supervision, students develop their own projects within prescribed research fields.
Qualification goals	On completion, students should be able to • understand the theoretical and methodological contexts of the project in hand, and to autonomously acquire new knowledge and skills in the respective area of research.

	• apply familiar methods and work methods from pharmaceutical biology and biotechnology to new questions. • research relevant literature for the project in hand (supervised). • plan, conduct, evaluate, and document scientific experiments (supervised), and to interpret the results. • work in a team. • structure and schedule a project.
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	Prof. Dr. R. Fürst, Prof. Dr. E. Wagner, Prof. Dr. S. Zahler
Language(s) of instruction	German
Other information	

Module: WP 3 Research internship – Pharmaceutical technology

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Laboratory course	WP 3.1 / I Modern methods of pharmaceutical technology	SS	90 h (6 SWS)	0 h	(3)
Laboratory course	WP 3.1 / II Modern methods of pharmaceutical technology	WS	90 h (6 SWS)	0 h	(3)

In this module, students must acquire a total of 6 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 180 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	Successful completion of P 9
Semester of degree course	Recommended semester: 4 and 5
Duration	This module lasts for 2 semesters.
Contents	In the **elective module**, students gain first insights into pharmaceutical research. Under supervision, they work according to scientific aspects on closely defined projects which are relevant to actual current research, in the field of pharmaceutical technology. Students learn in more depth about the theory and about basic methodological skills and work methods in the field of pharmaceutical technology. Under supervision, students develop their own projects within prescribed research fields.
Qualification goals	On completion, students should be able to • understand the theoretical and methodological context of the project in hand, and to autonomously acquire new knowledge and skills in the respective area of research. • apply familiar methods and work methods from pharmaceutical technology to new questions. • research relevant literature for the project in hand (supervised).

	• plan, conduct, evaluate, and document scientific experiments (supervised), and to interpret the results. • work in a team. • structure and schedule a project.
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	Prof. Dr. W. Frieß, Prof. Dr. O. Merkel
Language(s) of instruction	German or English
Other information	

Module: WP 4 Research internship – Pharmacology

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Laboratory course	WP 4.1 / I Modern methods of pharmacology	SS	90 h (6 SWS)	0 h	(3)
Laboratory course	WP 4.1 / II Modern methods of pharmacology	WS	90 h (6 SWS)	0 h	(3)

In this module, students must acquire a total of 6 ECTS. Compulsory attendance: 12 periods per week during the semester. Taking personal studies into account, around 180 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	Successful completion of P 2 and regular attendance at P 6.3
Semester of degree course	Recommended semester: 4 and 5
Duration	This module lasts for 2 semesters.
Contents	In the **elective module**, students gain first insights into pharmaceutical research. Under supervision, they work according to scientific aspects on closely defined projects which are relevant to actual current research, in the field of pharmacology. Students learn advanced theory and basic methodological skills and work methods in the field of pharmacology. Under supervision, students develop their own projects within prescribed research fields.
Qualification goals	On completion, students should be able to • understand the theoretical and methodological context of the project in hand, and to autonomously acquire new knowledge and skills in the respective area of research. • apply familiar methods and work methods from pharmacology to new questions. • research relevant literature for the project in hand (supervised).

	• plan, conduct, evaluate, and document scientific experiments (supervised), and interpret the results. • work in a team. • structure and schedule a project.
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	Prof. Dr. M. Biel, Prof. Dr. S. Koch
Language(s) of instruction	German or English
Other information	

Module: P 14 Pharmacology

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 14.1 Basic principles of pharmacology 1	WS	60 h (4 SWS)	30 h	(3)
Lecture	P 14.2 Basic principles of pharmacology 2	SS	60 h (4 SWS)	120 h	(6)

A total of 9 ECTS must be acquired in the module. Compulsory attendance: 8 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 5 and 6
Duration	This module lasts for 2 semesters.
Contents	The **module** covers the basic principles of pathophysiology, pathology, and pharmacology. Building on the basic molecular, cellular, and systemic principles of diseases, this module explores the effects of important classes of pharmaceutical drugs. It also provides insights into the clinical aspects of using pharmaceutical drugs. Both parts of the lectures focus on the following themes: Part 1 • Basic principles of pharmacodynamics and pharmacokinetics • Pharmacology of the autonomic nervous system • Kidney and cardiovascular system • Pharmacology of the endocrine system • Pharmacology of the gastrointestinal tract Part 2 • Blood and the immune system • Anti-infectives • Pharmacology of tumour diseases • Inflammation, pain • Pharmacology of the CNS

Qualification goals	On completion, students should be able to • describe the basic principles of the pathophysiological processes which lead to diseases. • understand the basic laws, models, and concepts governing pharmacodynamics and pharmacokinetics. • describe the effects of important classes of pharmaceutical drug, taking not only the direct interaction of the drugs with receptors into account, but also downstream signal transduction processes. • outline the clinical aspects of pharmaceutical drug effects (e.g., treatment regimes, interactions, etc) for selected illnesses (e.g., contagious diseases, cancer, diabetes, high blood pressure).
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. M. Biel
Language(s) of instruction	German
Other information	

Module: WP 5 Vocational qualification module – Scientific writing

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Excursion	WP 5.1 Excursion to a company in the pharmaceutical industry	WS	15 h (1 SWS)	15 h	(1)
Seminar	WP 5.2 Scientific Writing	WS	15 h (1 SWS)	45 h	(2)

In this module, students must acquire a total of 3 ECTS. Compulsory attendance: 2 periods per week during the semester. Taking personal studies into account, around 90 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 7.
Prerequisites for participation	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 5
Duration	This module lasts for 1 semester.
Contents	In this **module,** relevant job skills are taught. During the **excursion** to one or more companies in the pharmaceutical industry, students gain basic insights into the profession and the areas of work in which scientists are involved in the pharmaceutical industry. In the ***Scientific writing*** **seminar,** students learn the basic principles of scientific writing and publishing. Using example texts, students learn about the typical structure of various types of scientific publications such as final dissertations, articles, letters and reviews. The process for publishing a piece of scientific writing is explained. Students learn how to design tables, illustrations and diagrams, and how to quote in accordance with scientific protocol. They are taught the basic techniques for scientific writing and reasoning (hypotheses, experiments, insights, discussion and summary), and put these into practice by writing a brief scientific text in English.
Qualification goals	On completion, students should be able to • use the insights they have gained in their work

	experience and in talking to scientists from the pharmaceutical industry to assess the requirements on the international job market. • identify their own interests and aspirations, and plan their future career. • outline the most important types of scientific publications, their functions, and their typical structures. • understand the process involved when publishing a piece of scientific writing. • draft and write short scientific texts which include tables, illustrations and diagrams, in the English language.
Type of module examination	Excursion report
Type of assessment	Grades are not given for this module.
Preconditions for receiving ECTS	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	Dean of studies
Language(s) of instruction	German or English
Other information	

Module: WP 6 Vocational qualification module – Scientific presentation

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Excursion	WP 6.1 Excursion to a company in the pharmaceutical industry	WS	15 h (1 SWS)	15 h	(1)
Seminar	WP 6.2 Scientific Presentation	WS	15 h (1 SWS)	45 h	(2)

In this module, students must acquire a total of 3 ECTS. Compulsory attendance: 2 periods per week during the semester. Taking personal studies into account, around 90 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 7.
Prerequisites for participation	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 5
Duration	This module lasts for 1 semester.
Contents	In this **module,** relevant job skills are taught. During the **excursion** to one or more companies in the pharmaceutical industry, students gain basic insights into the profession and the areas of work in which scientists are involved in the pharmaceutical industry. In the ***Scientific presentation*** **seminar,** students learn the basic principles for presenting scientific data and insights. These include, among other things: • the structure of a scientific presentation • visualisation rules and selection of media • using presentation software • data presentation, drawing software, animations • basic rhetoric • basic principles of public presentation and leading discussions The students learn to prepare and give short presentations on current scientific topics in the field of regulatory affairs.

	In introductory seminars, the students are taught the basics of national and international drug approval, pharmacovigilance and drug pricing.
Qualification goals	On completion, students should be able to • use the insights they have gained in their work experience and in talking to scientists from the pharmaceutical industry to assess the requirements on the international job market. • identify their own interests and aspirations, and plan their future career. • structure and illustrate scientific data and results. • prepare and give scientific lectures in a register appropriate to the target group. • design and present a scientific poster. • host a scientific discussion appropriately.
Type of module examination	Excursion report
Type of assessment	Grades are not given for this module.
Preconditions for receiving ECTS	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	Dean of Studies
Language(s) of instruction	German or English
Other information	

Module: WP 7 Vocational qualification module – Patent law

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Excursion	WP 7.1 Excursion to a company in the pharmaceutical industry	WS	15 h (1 SWS)	15 h	(1)
Seminar	WP 7.2 Patent law for pharmaceutical sciences	WS	15 h (1 SWS)	45 h	(2)

In this module, students must acquire a total of 3 ECTS. Compulsory attendance: 2 periods per week during the semester. Taking personal studies into account, around 90 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 7.
Prerequisites for participation	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 5
Duration	This module lasts for 1 semester.
Contents	In this **module,** relevant job skills are taught. During the **excursion** to one or more companies in the pharmaceutical industry, students gain basic insights into the profession and the areas of work in which scientists are involved in the pharmaceutical industry. In the ***Patent Law*** **seminar,** students are taught the basic principles of German, European, and international patent law, with practical examples from the field of patenting pharmaceutical inventions. Topics include: • basic property rights • the definition of an invention, requirements for patents, and the legal implications of patent claims • patent research • the procedure for patents, the structure and course of registering a patent • the résumé and implications of a patent • the Employee Inventions Act

Qualification goals	On completion, students should be able to • use the insights they have gained in their work experience and in talking to scientists from the pharmaceutical industry to assess the requirements on the international job market. • identify their own interests and aspirations, and plan their future career. • outline the basic principles of German, European, and international patent laws and systems. • research and evaluate patents in the field of pharmaceutical drugs.
Type of module examination	Excursion report
Type of assessment	Grades are not given for this module.
Preconditions for receiving ECTS	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	Dean of Studies
Language(s) of instruction	German
Other information	

Module: P 15 Advanced pharmaceutical technology

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Lecture	P 15.1 Pharmaceutical technology – phase systems	SS	30 h (2 SWS)	60 h	(3)
Laboratory course	P 15.2 Advanced pharmaceutical technology (laboratory course)	SS	90 h (6 SWS)	90 h	(6)
Laboratory course	P 15.3 Project work Pharmaceutical technology	SS	45 h (3 SWS)	45 h	(3)

In this module, students must acquire a total of 12 ECTS. Compulsory attendance: 11 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 6
Duration	This module lasts for 1 semester.
Contents	The **module** covers special aspects of manufacturing pharmaceutical drugs, with practical applications. Students primarily engage in (unsupervised) project work. In the **lectures,** students are taught basic aspects of liquid and sterile types of pharmaceutical drugs. This is taught in the context of industrial pharmaceutical drug manufacture. Amongst other things, students learn about the aspects of physical chemistry and special equipment which need to be taken into account in manufacture. In this connection, students are introduced to modern test methods for the characterization of various types of pharmaceutical drugs, as well as raw materials and intermediate products. In the **advanced laboratory course,** students learn about modern manufacturing and analysis techniques, using practical examples such as tablets, capsules, granulates, emulsions, suspensions, colloidal preparations, inhalants, eye drops, and injection solutions, and about drug delivery systems such as liposomes, nanoparticles and oral modified-release forms. Students also practice more

	complex pharmaceutical processes such as various drying, freezing, pelletising, and sterilizing processes. In unsupervised **project work**, students learn to apply the skills they have learned practically to special questions of drug development, manufacture, or characterization, and get to grips with current scientific questions relating to the manufacture of pharmaceutical drugs.
Qualification goals	On completion, students should be able to • understand and consistently apply the microbiological quality of pharmaceutical drugs and the corresponding safety measures during manufacture. • competently answer and explain questions relating to the manufacture of pharmaceutical drugs. • plan, perform and document manufacturing processes, even those which involve the use of complex equipment, using the appropriate settings and selecting the necessary auxiliary agents. • test and evaluate types of pharmaceutical drugs concerning their critical parameters. • integrate theory and handle complexity. • autonomously acquire new knowledge and skills. • complete application-based projects with little or no supervision.
Type of module examination	oral examination
Type of assessment	Grades are given for this module.
Preconditions for receiving ECTS	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. W. Frieß, Prof. Dr. O. Merkel, Dr. K. Prüßmann
Language(s) of instruction	German or English
Other information	

Module: P 16 Final module

Assigned to degree	Bachelor's degree: Pharmaceutical Sciences (Bachelor of Science, B.Sc.)

Associated modules

Course type	Event (compulsory)	Semester	Classroom hours	Self-study	ECTS
Bachelor's thesis	P 16.1 Bachelor's thesis	WS and SS	-	360 h	(12)

In this module, students must acquire a total of 12 ECTS. Compulsory attendance: 0 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	See Annexe 2 of the ESR dated March 18, 2016
Semester of degree course	Recommended semester: 6
Duration	This module lasts for 1 semester.
Contents	For their **bachelor's thesis**, students write their own scientific thesis (supervised) on a topical issue from pharmaceutical science.
Qualification goals	On completion, students should be able to • work to a deadline to plan a scientific dissertation on a topical issue from pharmaceutical science, and to structure and write the dissertation according to scientific conventions. • research the relevant literature required for the dissertation by themselves. • formulate hypotheses to solve the respective scientific question, and test these experimentally. • plan, conduct and evaluate scientific experiments (supervised), document these following the rules of "Good Scientific Practice", and interpret, question and categorise the results in the context of published insights.
Type of module examination	Bachelor's thesis
Type of assessment	Grades are given for this module.

Preconditions for receiving ECTS	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	
Language(s) of instruction	German or English
Other information	