Module catalogue for the master’s course

Molecular Medicine

Obligatory modules

Module number	**MOLMED-O.1**
Module title	**Human genetics**
Person in charge	
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester
Credit points (ECTS credits)	6
Workload in: - Contact hours - Self-study (including exam preparation)	 90 h 60 h
Language of instruction	The module is taught in English.
Content	The seminar „Introduction to Human Genetics“ headed by Prof. Dr. Baniahmad presents inherited diseases, for which the mechanisms, the modes of inheritance and molecular pathways will be discussed. The lecture „Molecular Human Genetics” held by Prof. Dr. Norgauer and Dr. Oberle is focused on diagnostics including prenatal diagnostics, detection and molecular genetics, chromosomal aberrations and transplantation genetics. The lecture “Human Genetics” by PD Dr. Liehr is focused on the identification, inheritance modes of human diseases from cytogenetic to molecular changes, such as imprinting and genetic anticipation. Novel technical approaches used to elucidate such alterations are discussed in the lectures.
Educational and qualification objectives	Students will increase their knowledge about the most important clinical problems of the subject (disease patterns, diagnostic procedure), therapies currently customary and important fields of research of the specialist area.
Admission requirements for the module exam	Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Examination (50 %) and seminar 50%
Recommended literature	Literature will be recommended at the beginning of the course.

Module number	**MOLMED-O.2**
Module title	**Clinical chemistry/Molecular diagnostics**
Person in charge	PD Dr. Dr. M. Kiehntopf, Prof. Dr. C. Hoffmann
Admission requirements for the module	none
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture, seminars and practical exercises: 3 contact hours per week
Credit points (ECTS credits)	6
Workload in: - Contact hours - Self-study (including exam preparation)	 90 h 60 h
Language of instruction	The module will be taught in English
Content	Overall, the module aims to introduce pathological biochemistry in patients and the use of biomarkers to indentify these individuals. In summer, the principles of commonly used biochemical, cytological and molecular biological methods are presented. The laboratory work-up for detection and monitoring of disease and therapy control is discussed. An additional focus lies on DNA-based investigations in routine diagnostic as well as research settings. Within this context the students are introduced to classical mutation detection, massive parallel sequencing, copy number screening and identification of epigenetic alterations. Lectures cover an introduction to pathological biochemistry, diagnostically relevant metabolites, substrates and enzyme activities; flow cytometry, diagnostic hematology, endocrinology and hemostasiology. Further topics are diagnostic molecular biology and mass spectrometry methods as well as their application in routine diagnostics and clinical research (e.g. biomarker identification). Several *in silico* tools (genome browsers, sequence alignment options, primer design software etc.) are presented; their use to solve specific problems is part of the practical classes. Furthermore, the module will give an introduction into the basic principles of optical detection methods (e.g. fluorescence microscopy or Förster resonance energy transfer (FRET) measurements) of cellular structures and physiological signaling mechanisms. The lectures will touch the physical basics of fluorescence and give an introduction into chemical assays that can be used on the stage of a light microscope to analyze and monitor biological processes with a subcellular resolution. Fluorescence labeling techniques and the mechanisms, on which indicators and biosensors are based, will be explained.

	Seminars will be devoted to the discussion of original literature related to the topics of the lectures. Experiments will help to put the theory into praxis.
Educational and qualification objectives	• Acquiring basic knowledge of biomarker detection and application in molecular diagnostics • Acquiring basic knowledge of pathological biochemistry in selected organs • Application of diagnostic methods (biomarkers) to identify selected diseases • Understanding of basic optical principles • Application of fluorescence techniques • Introduction into advanced optical techniques
Admission requirements for the module exam	Confirmed attendance at practical training, successful completion of practical tasks
Requirements for the award of credit points (Weighting of grades in %)	Written exam in clinical chemistry (50 %) Written exam for microscopic techniques (50 %)
Recommended literature	Literature will be recommended at the beginning of the course.

Module number	**MOLMED-O.3**
Module title	**Medical biometry**
Person in charge	Dr. L. Leistritz, Dr.-Ing. K. Schiecke
Admission requirements for the module	none
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly, each winter semester
Duration of module	1 semester
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 2 contact hours per week per semester
Credit points (ECTS credits)	4
Workload in: - Contact hours - Self-study (including exam preparation)	 60 h 60 h
Language of instruction	The module is taught in English
Content	The lecture course imparts basics, fundamental terms, and conditions of biomedical data analysis. The courses are given in groups of ten to twenty students by involving the statistical software SPSS. This group size enables each student to use an own workstation during the course. The following subjects are concerned: fundamentals of the theory of probabilities, fundamental terms of epidemiology, descriptive statistics, diagnostic tests, random variables, particular probability distributions, estimations, statistical tests, multiple testing, Bootstrapping, correlation, regression, design and execution of experiments.
Educational and qualification objectives	The students learn basic principles of the mathematical statistics and are familiarized with the statistical thinking. The students will be enabled to apply exemplarily statistical methods to biomedical data.
Admission requirements for the module exam	Proof of attendance at 80% of the exercises as well as all SPSS seminars.
Requirements for the award of credit points (Weighting of grades in %)	Written examination (100 %)
Recommended literature	Literature will be recommended at the beginning of the course.

Module number	**MOLMED-O.4**
Module title	**Molecular pathology**
Person in charge	PD Dr. Jörg Müller
Admission requirements for the module	none
Usability (required for)	Required for admission to the module MOLMED-O.6, (special problems of molecular pathology) and to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 3 contact hours per week per semester seminar and exercise: 3 contact hours per week per semester
Credit points (ECTS credits)	8
Workload in: - Contact hours - Self-study (including exam preparation)	 104 h 100 h
Language of instruction	The module is taught in English.
Content	Lectures (given by colleagues of the CMB, of the Institute of Pathology, and work area of Neurophathology) will cover the molecular basis of pathogenesis and therapy of important disease entities. These involve cancer, cardiovascular, and infectious diseases. Basic terms of pathology and the position of this discipline in research and patient care will be explained. Distinguishing different types of cell and tissue lesions will be demonstrated with the help of macroscopic and microscopic tissue preparations. The use of microscopy to judge histological preparations will be practised in exercises. The part neuropathology will provide knowledge about the molecular reasons for neurological diseases and its application for diagnosis and therapy. Attention will be paid to frequent neurodegenerative diseases, including *M. Parkinson* and *Alzheimer* dementia. Rarer diseases, for which uncovering molecular causes has contributed much to the understanding of function and dysfunction in the central nervous system will also be discussed (e.g. *Chorea Huntington*). Further topics will be genetic changes in malignant brain tumours and their import- ance for chemotherapy and prognosis, as well as the pathogenic functions of ion channels. Seminars will be devoted to discussion of concurrent original literature related to the different lecture topics. In addition, methods with relevance for molecular pa- thology will be presented (IHC, IHS, FISH and PCR/RT- PCR in histological preparations, expression cluster- analysis, comparative genomic hybridization).
Educational and qualification objectives	Students will develop a profound understanding of molecular causes and of the pathological appearance of

	important groups of diseases. Also they will be sensitized for problems of most current research und are able to make interdisciplinary connections to the content of the specialty subjects.
Admission requirements for the module exam	Documented active participation in microscope exercises and successful completion of the necessary seminar contributions.
Requirements for the award of credit points (Weighting of grades in %)	Written examination (60%), oral examination - histology course (40%)
Recommended literature	Literature will be recommended at the beginning of the course.

Module number	**MOLMED-O.5**
Module title	**Molecular pharmacology**
Person in charge	Prof. Dr. R. Stumm
Admission requirements for the module	none
Usability (required for)	Required for admission to the module MOLMED-O.7, (special problems of molecular pharmacology) and to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar and exercise: 2 contact hours per week per semester
Credit points (ECTS credits)	6
Workload in: - Contact hours - Self-study (including exam preparation)	 120 h 80 h
Language of instruction	The module is taught in English
Content	The Module offers basic knowledge of general Pharmacology and Toxicology. The complex interrelations of drugs and their pharmacological targets in the hu- man organism will be explained and exemplified. The lectures and seminars are aimed to permit key skills of pharmacokinetics and - dynamics as well as knowledge on the complex effects and interferences of pharmaceutics. The initial lessons of the subsequent subjects of special pharmacology and toxicology introduce the activity spectrum of selected drugs affecting cellular growth and expression processes. These groups of drugs in- clude antimicrobial substances, immunosuppressive pharmaceutics, cytostatics, derivatives of steroids and antidiabetics. The tutorial program interconnects the medical and pharmacological activity pattern of these substances with their molecular, cellular and organismic effects and functions. Selected effectors of ion transport and synaptic transmission complete the lec- tures and seminars of the module. All students contribute presentations on specific topics to the seminars. Oral examination is in every semester. To warrant balanced control of all contents, both examinations must be passed. Both examinations are equally enlisted.
Educational and qualification objectives	Students will develop enhanced understanding of the molecular basis of complex correlations between active substances and their pharmacological target structure in the human organism.
Admission requirements for the module exam	Active and continuous attendance (87.5 %) on lectures and seminars.
Requirements for the award of	Written examination (100%).

credit points (Weighting of grades in %)	
Recommended literature	Literature will be recommended at the beginning of the course.

Module number	**MOLMED-O.6**
Module title	**Current topics of molecular pathology**
Person in charge	Prof. Dr. I. Rubio
Admission requirements for the module	Successful completion of the module molecular pathology, MOLMED-O.4
Usability (required for)	Required for admission to the module MOLMED-PM.3 (master's thesis)
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly
Duration of module	1 Semester
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 2 contact hours per week per semester
Credit points (ECTS credits)	8
Workload in: - Contact hours - Self-study (including exam preparation)	 64 h 150 h
Language of instruction	The module is taught in English.
Content	The lecture series (held by members of the CMB plus additional specialists in corresponding lecture topics) will expose and discuss the molecular causes and molecular-based therapy approaches for a range of human diseases such as cancer, inflammatory diseases, and metabolic disorders. Each student will hold a seminar, which requires an increased input of initiative learning. In the seminars students will deal with original studies related to the lecture topics. Seminars follow both in terms of timeline and contents on the corresponding lectures and are tutored by the same lecturer.
Educational and qualification objectives	Students will develop enhanced understanding of molecular causes for important groups of diseases. They will be sensitized for problems of most current research und are able to make interdisciplinary connections to the content of the specialty subjects.
Admission requirements for the module exam	Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Written examination (100%).
Recommended literature	Literature will be recommended at the beginning of the course.

Module number	**MOLMED-O.7**
Module title	**Current topics of molecular pharmacology**
Person in charge	Prof. Dr. R. Heller
Admission requirements for the module	Successful completion of the module molecular pharmacology, MOLMED-O.5
Usability (required for)	Required for admission to the module MOLMED-PM.3 (master's thesis)
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly
Duration of module	1 Semester
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 2 contact hours per week per semester
Credit points (ECTS credits)	7
Workload in: - Contact hours - Self-study (including exam preparation)	 60 h 120 h
Language of instruction	The module is taught in English.
Content	This module combines the knowledge of molecular pharmacology (MSO-5) with recent insights of bioor- ganic chemistry and new findings of medical, pharma- cological and cell biological research. The focus of the modul lies on the principles of target-oriented drug design. Selected examples will be used to demonstrate typical structural properties and struc- ture-function relationships of drugs as well as the itera- tive processes of lead compound screening and opti- mization of activity profiles of the compounds. Further, specific drugs and their respective targets with particu- lar relevance to the treatment of neurological, inflam- matory, cardiovascular and oncological diseases will be introduced. In this context, a special emphasis will be given to drug targets that are investigated at the university of Jena (G-protein-coupled receptors, recep- tor tyrosin kinases and other protein kinases, ion chan- nels). In addition, the role of natural compounds as starting substances for the development of drugs will be discussed. The modul is aimed to provide an understanding of functional patterns of drugs on a structural, molecular, cellular and organ-specific level. It will involve latest scientific findings and establish connections with other elective subjects of the course in a comprehensive manner. The seminars comply with the lectures and will be supervised by the respective lecturers. In the seminars, students will discuss original publications related to the topics of the lectures (2 contributions per student), which will require an increased extent of self- study.
Educational and qualification objectives	Students will develop enhanced understanding of the molecular basis of the complex correlations between

	active substances and their pharmacological target structures. They will be sensitized for problems of most current research und are able to make interdisciplinary connections to the content of the specialty subjects.
Admission requirements for the module exam	Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Written examination (100%)
Recommended literature	Literature will be recommended at the beginning of the course.

Project modules

Module number	**MOLMED-PM.1**
Module title	**Project planning**
Person in charge	University teacher in charge of the respective project
Admission requirements for the module	Successful completion of MOLMED-O.1-3 and of the elected specialty subjects
Usability (required for)	Required for admission to the master's thesis
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly
Duration of module	3 months
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	Practical training: 4 contact hours per week per semes- ter
Credit points (ECTS credits)	8
Workload in: - Contact hours - Self-study (including exam preparation)	60 h (practical training in the laboratory) 180 h (project related)
Language of instruction	English or German (depending on the language skills of the students)
Content	The module project planning serves the definition of the content of the master's thesis's and of the pro- posed introductory project. For this purpose at least one working title must be analyzed for academic rele- vance and feasibility. The topics may be selected from all areas of molecular medicine. The tutor should be a teacher at the school of medicine.
Educational and qualification objectives	Independent project planning; acquirement of special- ized knowledge in the field of the planned master's thesis.
Admission requirements for the module exam	Compilation of a work plan for the introductory project for the master's thesis, e. g. as a presentation
Requirements for the award of credit points (Weighting of grades in %)	Positive assessment of the work plan by the university teacher in charge (100%)
Recommended literature	English language original literature relevant to the project.

Module number	**MOLMED-PM.2**
Module title	**Introductory project for the master's thesis**
Person in charge	University teachers in charge of the respective project
Admission requirements for the module	Successful completion of MOLMED-PM.1 (project planning)
Usability (required for)	Required for admission to the master's thesis
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly
Duration of module	3 months
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	Practical training: 4 contact hours per week per semes- ter
Credit points (ECTS credits)	7
Workload in: - Contact hours - Self-study (including exam preparation)	60 h (practical training in the laboratory) 180 h (project related)
Language of instruction	English or German (depending on the language skills of the students)
Content	The introductory serves the specific preparation of the master's thesis. For this purpose the feasibility of the experimental approaches identified during project planning will be specifically tested and first data on the problems of the master's thesis will be gathered. As a result the plan for the master's thesis will be further developed and modified if necessary. The tutor should be a teacher at the school of medicine.
Educational and qualification objectives	Acquirement of experimental methods and special knowledge essential for completing the planned mas- ter's thesis.
Admission requirements for the module exam	Compilation of a work plan for the master's thesis, e. g. as a presentation
Requirements for the award of credit points (Weighting of grades in %)	Positive assessment of the work plan by the university teacher in charge (100%)
Recommended literature	English language original literature relevant to the project.

Module number	**MOLMED-PM.3**
Module title	**Master's thesis**
Person in charge	University teachers in charge of the respective project
Admission requirements for the module	Successful completion of MOLMED-O.7 (introductory project)
Usability (required for)	Required for completion of studies.
Type of module (obligatory, required elective, elective)	Obligatory module
Frequency of offer (Cycle)	Yearly
Duration of module	6 months
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	Practical training: 10 contact hours per week per semester
Credit points (ECTS credits)	30
Workload in: - Contact hours - Self-study (including exam preparation)	 150 h 750 h (project related)
Language of instruction	English
Content	An experimental problem of molecular medicine will – with continual consultations – be independently worked on and the data will be analyzed according to the rules of good laboratory practice. The master's thesis will be written by the student independently and contains a critical appraisement of current specialist literature. The tutor should be a teacher at the school of medicine.
Educational and qualification objectives	Ability to experiment independently, critical appraise- ment of the work result and editing of the data. Ability to compose an extended academic paper.
Admission requirements for the module exam	Presentation of the master's thesis
Requirements for the award of credit points (Weighting of grades in %)	Positive assessment of the master's thesis and of the presentation of its results (15 minutes in English) by the university teacher in charge (67%) as well as by the second advisor (33%).
Recommended literature	English language original literature relevant to the project.

Specialization modules (required elective modules)

Two specialization modules in any combination may be elected

Module number	**MOLMED-S.1**
Module title	**Molecular intensive care**
Person in charge	Prof. Dr. Markus Gräler / apl.-Prof. Ralf A. Claus
Admission requirements for the module	None
Usability	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semester
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	English language
Content	The module provides an overview on diagnostics and therapy as well as areas of active research in the field of molecular intensive care medicine. Exemplarily, ischemia/reperfusion, systemic inflammation/sepsis and failure of lung and liver will be covered. The lectures will be complemented by a seminar allowing in depth discussions in an interdisciplinary manner between clinicians and basic scientists. Each student will present two talks within the seminar. Lecture and seminar will include bed- side-teaching and presentation of the syndromes discussed. A translational practical teaching will be provided within our experimental section 'Molecular Mechanisms of Organ Failure' as well as 'Sepsis Research'.. A broad spectrum of molecular techniques with emphasis on systems biology will be taught.
Educational and qualification objectives	Documented active participation in seminar, completed experimental project including report
Most important molecular methods	qPCR, metabolomic and bioinformatic analyses
Admission requirements for the module exam *	Documented completion of the experimental project paper Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Written examination (lectures, seminars); closing report (practical training) 50 % each

Recommended literature	Bosshart H, Heinzelmann M (2007) Targeting bacterial endotoxin: two sides of a coin. Ann N Y Acad Sci. 1096:1- 17. Opal SM (2003) Severe sepsis and septic shock: defining the clinical problem. Scand J Infect Dis. 35:529-34. Verstak B, Hertzog P, Mansell A (2007) Toll-like receptor signalling and the clinical benefits that lie within. Inflamm Res. 56:1-10. Guo RF, Ward PA (2005) Role of C5a in inflammatory responses. Annu Rev Immunol. 23:821-52. Clark IA. (2007) How TNF was recognized as a key mechanism of disease. Cytokine Growth Factor Rev. 18:335-43. Hotchkiss RS, Nicholson DW (2006) Apoptosis and caspases regulate death and inflammation in sepsis. Nat Rev Immunol. 6:813-22. Beutler B (2002) Toll-like receptors: how they work and what they do. Curr Opin Hematol. 9:2-10. Roeder A, Kirschning CJ, Rupec RA, Schaller M, Korting HC (2004) Toll-like receptors and innate antifungal responses. Trends Microbiol 12:44-9. Winning J, Claus RA, Huse K, Bauer M (2006) Molecular biology on the ICU. From understanding to treating sepsis. Minerva Anestesiol 72:255-67 Bauer M, Coldewey SM, Leitner M, Loffler M, Weis S, Wetzker R (2018) Deterioration of Organ Function as a hallmark in Sepsis: the cellular Perspective. Front. Immunol 2018 Jun 26; 9: 1460.

Module number	**MOLMED-S.2**
Module title	**Gynecology and obstetrics**
Person in charge	Prof. Dr. M. Dürst
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semes ter
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	The module will be taught in English
Content	This module covers three key topics pertinent to gynecology and obstetrics: (1) gynecological endocrinology and reproductive medicine (Justine Fitzgerald), (2) pregnancy and perinatal medicine (Udo Markert) and (3) gynecological molecular biology (Matthias Dürst). Lectures will focus on hormonal regulation, basics and methods in reproductive medicine, stem cell diagnostics and reproduction genetics. The second block of lectures will cover materno-fetal interaction, reproduction immunology and molecular mechanisms of placental regulation. The final series of lectures will be on gynecological malignancies and will include tumor classification, molecular markers for tumor screening and prognosis, mechanisms in tumorigenesis and innovative therapies. The seminars will be used to discuss related topics and to provide insight into the most recent research activities within the field. For practical training the students will participate in ongoing re- search activities of the laboratory. Thereby they will be given the opportunity to acquire a broad range of molecular biological skills.
Educational and qualification objectives	The students will get an overview on molecular mechanisms involved in gynecological diseases and disorders. The aim is to understand the processes at a clinical and molecular level. Moreover, the students will be taught to critically read and discuss recent research articles. The practical training focuses on a selected research field. Thereby, the student will learn to plan, coordinate, execute, interpret and document their experimental work.
Most important molecular methods	Interphase FISH; matrix CGH; FACS; in situ hybridization; micro dissection of tissue; micro-array analyses

	(cDNA, CpG); real-time PCR; Southern, Northern and Western blots; plasmid construction (S2 level); gene transfection and transduction; functional assays in cell cultures
Admission requirements for the module exam	Documented completion of the experimental project paper. Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Testate (oral examination). Successful completion of the experimental practical training, submission of a written and oral (short presentation) report on the practical training. Weighting of grades: testate lecture/seminar: 60%, Report on practical training and presentation: 40%
Recommended literature	Literature will be recommended at the beginning of the course.

Module number	**MOLMED-S.3**
Module title	**Stem cell research - applications in tissue engineering, cell therapy and as an *in vitro* model for testing drugs and environmental toxins**
Person in charge	Prof. Dr. Maria Wartenberg
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semes ter
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	English (partly German)
Content	The module provides an overview of current applications of stem cells (embryonic stem cells and adult stem cells) in therapy, e.g. in tissue engineering or cell therapy. Another focus is on the use of tissues differentiated from stem cells as an *in vitro* model (replacement of animal experiments) for the testing of drugs, additives, environmental toxins and for biocompatibility studies. This method can save hundreds of animal experiments and still make tissue-specific statements on risk assessment or biocompatibility. A flanking seminar program provides insights into the latest publications. Instructions for self-study are given. By participating in internships in stem cell research, the students learn the latest techniques of isolation, cell culture and targeted differentiation of different tissues and cell types from stem cells. Participation in ongoing research projects e.g. "Testing of active substances for the stability and aging of cardiomyocytes" or "Comparison of fat-derived stem cells from patients of different ages and genders with regard to their plasticity" is possible. Open questions and references to lecture content are discussed in consultations. The internship can flow smoothly into a preparatory course for a master's thesis if the topic is exciting and the interns enthusiastic. In the internship, all methodological basics and techniques are learned in order to be optimally prepared for a later master's thesis. The molecular proportion of the work in the internship is 80%.

Educational and qualification objectives	The students acquire basic knowledge about isolation, purification, cell culture and differentiation protocols of the most important stem cell types and their possible application in the clinic. They will learn all methods and techniques that are routine in the stem cell research group and are a prerequisite for the successful completion of master's and doctoral theses. The students also learn how to deal with current specialist literature on the topic and develop their own presentation on current research results. In the internship, the students work on relevant research tasks, carry out experiments themselves, evaluate them and interpret the test results. The test results are summarized in a presentation and presented to the working group. The experimental work may continue after successful completion and may be of direct benefit for a later thesis.
Most important molecular methods	Cell culture of embryonic stem cells, isolation and culture of adult stem cells from patient tissue, immunohistochemistry, western blot, working with phosphospecific antibodies, FACS, PCR techniques, transfections, shRNA, fluorescence-based physiological measurements (ROS, Ca2 + imaging, membrane potential measurements), confocal laser scanning microscopy.
Admission requirements for the module exam	Documented completion of the experimental project work as an oral presentation. Documented active seminar participation.
Requirements for the award of credit points (Weighting of grades in %)	Written exam (75%), Oral practice report (25%)
Recommended literature	Materials will be handed out at the beginning of the training course

Module number	**MOLMED-S.4**
Module title	**Molecular Genetics**
Person in charge	Prof. Dr. A. Baniahmad
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semester
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	The module will be taught in English.
Content	The lecture „Molecular Genetics“ provides insights into the structure and composition of the genome and molecular mechanisms of regulation of gene expression including epigenetics and hormonal regulation. The topic Genetics of Aging will be provided in a seminar series in which model organisms are genetically analyzed for genes involved in the aging processes. The practical course is focused on experimental analyses of gene expression (mRNA, proteomics) and cytogenetics. The part of molecular laboratory work will be about 80%.
Educational and qualification objectives	The students will get insights into molecular mechanisms of gene regulation in respect to human diseases. Students will give seminars of topics of novel literature of this field. Further, techniques analyzing gene expression at various levels will be provided.
Most important molecular methods	Cell culture, DNA probes, molecular detection methods
Admission requirements for the module exam	Documented completion of the experimental project paper. Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Examination (60%), project work (20%), lecture (20%)
Recommended literature	Materials will be handed out at the beginning of the training course.

Module number	**MOLMED-S.5**
Module title	**Oncology**
Person in charge	OA PD. Dr. S. Scholl
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semester
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	The lectures will be taught in German. The seminars and the practical training might also be taught in English.
Content	The module will give a comprehensive overview of different haematological and oncological diseases in cluding current concepts of diagnostic procedures and therapies. The seminar will focus on general molecular aspects of oncology as well as on special molecular mechanisms of different diseases (e.g. leukemia, lymphoma, solid tumors). The students will learn about data of clinical studies investigating the clinical benefit of new therapeutic approaches (e.g. tyrosine kinase inhibitors, demethylating agents, monoclonal antibod ies). The practical training focuses on experimental work in a specific research topic and will give an excellent teaching in laboratory praxis. The part of molecular laboratory work will be about 80%.
Educational and qualification objectives	The students will get insights in molecular mechanism in oncology. The module will give a comprehensive overview on basic molecular mechanisms underlying different entities of haematological and oncological diseases as well as on molecular aspects that are clinical relevant for prognostic stratification or representing the rationale for the application of certain “”targeted therapies”. The students acquire themselves knowledge on a specific research field by reading new publications and will give two independent lectures. In the practical training they will also focus on their specific research field and learn relevant molecular techniques.
Most important molecular methods	Molecular diagnostics (analyses of relevant mutations) including different PCR techniques, cytometry, western

	blot
Admission requirements for the module exam	Documented completion of the experimental project paper. Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Written examination (60%), project work (40%)
Recommended literature	Materials will be handed out at the beginning of the training course.

Module number	**MOLMED-S.6**
Module title	**Neurosciences**
Person in charge	Dr. Ch. Frahm / Dr. C. Schmeer
Admission requirements for the module	none
Usability (required for)	Required for admission to the module Modul-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	Lecture, Seminar, Practical training: 8 contact hour per week per semester
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	English
Content	This module focuses on the physiology and pathophysiology of the central nervous system. In particular, general aspects on the anatomy of the brain and visual system as well as on mechanisms involved in neuronal signaling, synaptic transmission, brain plasticity and learning, and neurogenesis are discussed. Since aging is the greatest risk factor for nearly all neurodegenerative diseases, emphasis is placed on age-associated pathologies i.e. stroke and other ischemic diseases. In addition, autoimmune diseases are analyzed in the context of genetic models and innovative molecular, immunological, electrophysiological and behavioral approaches. Furthermore, some insights into current and experimental therapeutic approaches are also provided. During the practical training, students are actively involved in ongoing research projects. The molecular biology content of the internship is ~80%
Educational and qualification objectives	The students get an insight into current research topics regarding the physiology and pathophysiology of the brain. In particular, there is a strong focus on basic neuronal mechanisms and brain function, involving plasticity and learning. During the practical training students work on selected research topics of neuroscience and learn relevant laboratory and scientific techniques. The acquired technical proficiencies in selected laboratory methods shall be applied in subsequent independent experiments of the students.
Admission requirements for the	qPCR, cloning, *in vitro* transcription, *in situ* hybridiza-

module exam	tion, siRNA studies, cell culture
Requirements for the award of credit points (Weighting of grades in %)	Written exam and seminars 50% / Practical training 50%
Recommended literature	**From Neuron to Brain: A Cellular and Molecular Approach to the Function of the Nervous System** (Englisch) Gebundene Ausgabe – 29. Februar 2012 von John Nicholls (Autor), ISBN-10: 0878936092, ISBN-13: 978-0878936090 **Principles of Neural Science (Principles of Neural Science (Kandel))** (Englisch) Gebundene Ausgabe – 26. Oktober 2012 von Eric R. Kandel (Autor), James H. Schwartz (Autor), Thomas M. Jessell (Autor), Steven A. Siegelbaum (Autor), A. J. Hudspeth (Autor), ISBN-10: 0071390111, ISBN-13: 978-0071390118 **Adult Neurogenesis (Cold Spring Harbor Monograph)** (Englisch) Gebundene Ausgabe – 30. November 2007 von Fred H. Gage (Herausgeber), Gerd, MD Kempermann (Herausgeber), Hongjun Song (Herausgeber); ISBN-10: 1598695606, ISBN-13: 978-0879697846 **Mouse Behavioral Testing** (Englisch) Gebundene Ausgabe – 2011 von Douglas Wahlstein (Author), ISBN: 978-0-12-375674-9 **Eye, Retina, and Visual of the Mouse** (Englisch) Gebundene Ausgabe – July 2008 von Leo M. Chalupa und Robert W. Williams (Herausgeber), ISBN: 9780262033817

Module number	**MOLMED-S.7**
Module title	**Rheumatology**
Person in charge	Prof. Dr. P. Oelzner
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semes ter
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	The module will be taught in English.
Content	Mechanisms of inflammation and tissue destruction in chronic rheumatic diseases (rheumatoid arthritis, connective tissue diseases especially systemic lupus erythematosus und systemic sclerosis, osteoarthritis, osteoporosis) including therapeutic targets/options and experimental models of these diseases. Mechanisms of bone destruction, impaired bone repair and disturbances of bone formation in chronic rheumatic diseases In detail: Regulation of bone resorption by the RANKL-RANK- OPG-system and by the IL-6 sytem Molecular mechanisms of proliferation and differentiation of osteoblasts including activation and inhibition of wnt-signaling AGE/RAGE-induced activation of fibroblasts in destructive arthropathies Role of synovial fibroblasts in the pathogenesis of rheumatoid arthritis Signal transduction in rheumatoid arthritis (with focus on synovial fibroblasts in vitro and ex vivo-studies of proliferation and differentiation of osteoblasts and influence of different treatments on this process Comparison of selective blocking of the proinflammatory TNF-Receptor 1 instead of the complete neutralisation of TNF-alpha, Neutralisation of proinflammatory monocytes/ macrophages by liposomal glucocorticoids and blocking of TNF Treatment of osteoporosis by bone replacemant therapy and growth factors, treatment of cartilage de-

	fects by newly developed cartilage matrix
Educational and qualification objectives	The students acquire intensive knowledge about molecular, cellular and system biological basics of rheu- matic diseases. They are able to recognize the clinical significance of rheumatic diseases including the use of diagnostic methods and modern tragets of therapy. During the practical training, the students work on a selected problem of science and learn relevant laboratory and scientific procedures. They acquire technical proficiencies in selected laboratory methods for independent application.
Most important molecular methods	RT- PCR, real time PCR, DNA sequencing, mutation analysis, in situ hybridization (blot, tissue), electrophoresis, Western blot, primary cell culture
Admission requirements for the module exam	Documented completion of the experimental project paper. Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Written examination (60%), Presentation & project work (40%)
Recommended literature	Materials will be handed out at the beginning of the training course.

Module number	**MOLMED-S.8**
Module title	**Transgenic animals**
Person in charge	Prof. Dr. Ch. A. Hübner
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semester
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	The module will be taught in English.
Content	In this module participants will get a survey on the advantages and disadvantages of different model organisms. The main focus will be the generation and analysis of genetically modified mice. Seminars will help to understand the methodological background of gene- traps, knockout, knockin, conditional and inducible strategies. Examples from the literature that are particularly relevant in the field will be presented by the participants (the literature will be provided). Practical work will be related to a specific scientific question. To address this question the participants will learn the relevant techniques. The molecular part at practical training in the laboratory ~ 70%.
Educational and qualification objectives	The practical course will help to acquire a profound knowledge on techniques for the manipulation of the mouse genome. Principle mouse phenotyping experiments will be covered as well.
Most important molecular methods	Molecular biology, Immunohistochemistry
Admission requirements for the module exam	Documented completion of the experimental project paper. Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Oral examination (67%), Presentation (33%)
Recommended literature	Materials will be handed out at the beginning of the training course.

Module number	**MOLMED-S.9**
Module title	**Medical Microbiology**
Person in charge	Prof. Dr. J. Rödel, Prof. Dr. C. Ehrhardt
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semes- ter
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	The module will be taught in English.
Content	The topics covered by the lecture are microbial virulence factors and molecular pathogenic mechanisms of infectious diseases. Some aspects of viral infections will be considered, but pathogenic bacteria are the main focus. The seminars focus on clinical microbiology (diagnostics, pathology, therapy, and case reports). The students will give talks on topics of their own interest. The practical course is organized as an experimental research course and the students will be involved in actual research projects. The practical course also includes work in the diagnostics laboratory with a special emphasis on molecular methods of identification and typing of bacteria and viruses. The part of molecular biology is *c.* 70%.
Educational and qualification objectives	The students are educated to – attain a deepened knowledge on molecular and cellular mechanisms of diseases caused by pathogenic microorganisms – practice oral presentation skills on the basis of self-studies and the use of original articles to use microbiological and molecular methods in diagnosis and infection research.
Most important molecular methods	PCR, siRNA techniques, LSM, immunoblotting
Admission requirements for the module exam	Documented completion of the experimental project paper. Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Written examination (50%) Practical course and protocol (25%) Seminar talk (25%)

Recommended literature	Materials will be handed out at the beginning of the training course. Recommended text books: Hahn H., Kaufmann S.H.E., Schulz T.F., Suerbaum S. Medizinische Mikrobiologie und Infektiologie, 6., überarb. Auflage 2009, Springer, Berlin Hof H., Dörries R. Medizinische Mikrobiologie, **4., überarb. Aufl. 2009, Thieme, Stuttgart**

Module number	**MOLMED-S.10**
Module title	**Medical Immunology**
Person in charge	Prof. Dr. T. Kamradt
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semester
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	The module will be taught in German & English.
Content	This model will provide a systematic introduction into molecular and cellular immunology and relevant clinical entitites (e.g. Immunodeficiency, Autoimmunity, Allergy, Transplantation), diagnostic methods and modern immunomodulatory therapies. The seminars will extend and support the material presented in the lecture series. They will deal with current scientific and clinical developments in immunology. Students will participate actively by presenting recent developments. To do so, they will be provided with relevant current original publications. The practical training will provide exposure to selected immunological techniques. Knowledge acquired during lectures and seminars will be applied and extended. Molecular techniques make up approximately 80% of the practical training.
Educational and qualification objectives	The students will acquire knowledge of the molecular. cellular, systemic, and clinical foundations of immunology. These will be presented with an orientation towards clinical relevance (immune-mediated diseases, immunological diagnostic methods, immunological treatment-options in immune-mediated and other diseases). In addition students will be exposed to current concepts and developments in immunology and learn to use immunological techniques.
Most important molecular methods	Antibody technologies, PCR, cloning, transfection, recombinant proteins, signal transduction, flow cytometry and cell sorting.
Admission requirements for the module exam	Documented completion of the experimental project paper. Documented active participation in the seminar
Requirements for the award of credit points	Written examination (50%), project work (30%), Seminar lecture (20%)

(Weighting of grades in %)	
Recommended literature	Materials will be handed out at the beginning of the training course.

Module number	**MOLMED-S.11**
Module title	**No module**

Module number	**MOLMED-S. 12**
Module title	**Gene-environment interaction in the developing and aging brain and associated disorders**
Person in charge	Dr. Olivia Engmann
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Häufigkeit des Angebots (Zyklus)	Yearly
Frequency of offer (Cycle)	1 semester
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 1 contact hours per week per semester seminar: 2 contact hour per week per semester practical training: 8 contact hours per week per semester
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	English
Content	The module provides an overview of environment-gene interactions in the context of the epigenetic modulation of gene expression during development, function and ageing of the brain as well as in associated neurological and neuropsychiatric diseases. First, chromatin architecture and regulatory signaling pathways are presented, then their intrinsic regulation (for example, during development and aging processes) is explained, and the influence of environmental factors (e.g., circadian rhythms, nutrition, and stress) will be elucidated. These concepts are then applied to neural illnesses that are affected by interactions between genetic, developmental, or environmental risk factors. Moreover, the concept of epigenetic inheritance is discussed and finally the latest epigenetic techniques (including CRISPR editing and chromatin capture approaches) and their relevance to the clinic will be introduced. In addition to an interactive lecture-seminar part, a practical course on CRISPR-epigenome editing will be performed, which enables the participants to learn the relevant techniques. The molecular part at practical training in the laboratory will be ~ 80%.
Educational and qualification objectives	The students will get insights into the relation between environment, genotype of individuals and susceptibility for common multifactorial neurological, neuropsychiatric and neurodegenerative diseases. Concerning the prevention of these diseases the risk calculation at molecular level is of special significance. Students will give seminars of topics of novel literature of this field. The practical training focuses on a selected

	research field including different laboratory techniques. Thereby, the students will learn to plan, coordinate, execute, interpret and document their experimental work.
Most important molecular methods	Cell culture, CRISPR-deadCas9 epigenome editing, DNA/RNA-Extraction, qPCR, PCR and pyrosequencing, immunofluorescence
Admission requirements for the module exam	Documented completion of the experimental project paper. Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Oral examination (67%), Presentation (33%)
Recommended literature	Materials will be handed out at the beginning of the training course.

Module number	**MOLMED-S. 13**
Module title	**Experimental Surgery**
Person in charge	Prof. Dr. U. Dahmen
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	compulsory elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week per semester seminar: 1 contact hour per week per semester practical training: 8 contact hours per week per semester
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	English
Content	The module gives an overview regarding the most important clinical and research challenges (disease, diagnostics, surgical therapy) in visceral and transplantation surgery with a focus on organ perfusion, ischemia reperfusion injury, rejection and regeneration and tumor. The accompanying seminar program serves to clarify open questions, to deepen the knowledge in respect to molecular pathways, to help improving self-directed learning and to promote literature work up (request for giving 2 seminar lectures respectively moderate scien tific discussions).
Educational and qualification objectives	Students will increase and deepen their knowledge about the most important clinical problems in the field in respect to etiology, diagnostic and treatment inclu ding surgical strategies. They have to acquire knowledge using current review and original papers and present the results of their literature work up. They will be trained in current laboratory techniques relevant in surgical research
Most important molecular methods	RNA isolation, cDNA synthesis, qPCR, protein expression, protein gel separation, Western blotting, silver staining, immune histochemistry, in situ hybridization
Admission requirements for the module exam	Documented active participation in the seminar
Requirements for the award of credit points (Weighting of grades in %)	Complete documentation of all experiments including a written scientific discussion of results (60%) Active participation in seminar program including 2 presentations (20%) Final report on practical course (10 %) Oral examination / final discussion (10 %)
Recommended literature	Current protocols

Module number	**MOLMED-S.14**
Module title	**Experimental Nephrology**
Person in charge	Prof. Dr. Ralf Mrowka
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	compulsory elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 1 contact hours per week per semester seminar: 2 contact hour per week per semester practical training: 8 contact hours per week per semester
Credit points (ECTS credits)	15
Workload in: **- Contact hours** **- Self-study (including exam preparation)**	165 h 240 h
Language of instruction	English
Content	Content of the module are the most relevant clinical aspects of nephrology base on the physiology and pathophysiology of the kidney. The module addresses primary kidney diseases and kidney involvement in systemic diseases such as diabetes and autoimmune disease. The student will learn about diagnostics and therapy of kidney disease. The seminars will allow discussing the topics interactively to gain a deeper understanding. The practical course work will focus on practical aspects of gene regulation research and opens the possibility to obtain skills in molecular lab techniques. The portion of the molecular part is approx. 80%.
Educational and qualification objectives	The students gain a deep understanding of the molecular, cellular, and systems biology related basics of kidney physiology and disease. The students will be able to present the physiological and pathophysiological aspects of kidney function and disease in the context of body function (excretion function, acid/base/balance/ endocrine function, and blood pressure regulation). The student will be able to understand current research questions in kidney research. The students will be able to understand research articles in the field of molecular aspects of kidney research. In the practical course work the student will get familiar with modern tools of molecular research. The students will be able to plan, to conduct, to document, to analyze and to interpret molecular experiments.
Most important molecular methods	qPCR, cell culture, transfection techniques, siRNA, promoter und UTR dependent reporter assays, transcription factor translocation assays with live cell imaging.

	Web based bioinformatical tools for planning and analysis
Admission requirements for the module exam	Documented project work, documented attendance of seminars
Requirements for the award of credit points (Weighting of grades in %)	Oral exam (60%) project work (20%) presentation (20%)
Recommended literature	ISBN 978-3-540-32908-4 chapter 29 30 35 Additional literature list will be given during the course

Module number	**MOLMED-S.15**
Module title	**Bioinformatics**
Person in charge	Prof. Dr. R. König
Admission requirements for the module	None
Usability (required for)	Required for admission to the module MOLMED-PM.1 (project planning)
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	lecture: 2 contact hours per week, in the winter term practical training: 9 contact hours per week, in the winter or summer term
Credit points (ECTS credits)	15
Workload in: - Contact hours - Self-study (including exam preparation)	 165 h 240 h
Language of instruction	Englisch
Content	The analysis of large datasets coming from functional genomics shows an increasing impact to the life science. Within the last years, a new sequencing technology came up which allows whole genome sequencing within days and gene expression microarrays were developed which enables gene expression profiling for nearly every gene of a cell. This data not only allows research at single genes of interest, but also the investigation of a larger part of cellular regulation. The lecture for this course will introduce several data analysis techniques for this data such as clustering which can identify gene groups with functional associations, or clustering of patients showing a similar molecular profile which may hint for e.g. disease subgroups, and building of a diagnostic tool employing classification techniques. Basic knowledge will be provided to analyse genomic sequences as e.g. alignments. The students will be introduced to the analysis of high throughput data, and in particular from gene expression, but also clinical data, and machine learning. The internship will deepen the knowledge and applied to our interesting current research topics. The molecular part is 50-80%.
Educational and qualification objectives	Pairwise and multiple alignments, dynamic programming, dotplot analysis, extreme value distributions, Dayhoff matrices, next generation sequencing technology, nomalization, clustering, machine learning (formal definitions, feature characteristics, learn strategies, evaluation of a classifier, some classifiers such as artificial neural networks or Support Vector Machines), propensity matching, R programming
Admission requirements for the module exam	Not needed
Requirements for the award of credit points (Weighting of grades in %)	At the end of the lecture course, a written exam will be performed covering the topics of the lecture. For the internship, a report needs to be written and handed in which will also be evaluated. This leads to two marks, one for the exam and one for the internship report. The mark for the whole module bases on the mark of the exam (34%) and the mark of the report (66%).
Recommended literature	David Mount, Bioinformatics, 2004, Cold Spring Harbor, Laboratory Frank, Witten, Data Mining, 2011, Morgan Kauffman, New York Peter Dalgaard, Introductory Statistics with R, 2008, Springer, Heidelberg Venables & Smith, Introduction to R, frei verfügbar, siehe www.r-project.org => Manuals

Module number	**MOLMED-S.16**
Module title	**Molecular biological approaches in medical research and diagnostics**
Person in charge	PD Dr. Jörg P. Müller
Admission requirements for the module	none
Usability (required for)	Prerequisite to start with MOLMED-PM.1
Type of module (obligatory, required elective, elective)	Required elective module
Frequency of offer (Cycle)	Yearly
Duration of module	2 semesters (WS and SS)
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	V: 2 SWS S: 1 SWS P: 8 SWS
Credit points (ECTS credits)	15 LP
Workload in: - Contact hours - Self-study (including exam preparation)	- 210 - 240
Language of instruction	English
Content	Introduction into practical aspects of molecular biological approaches and methods in medical research and diagnostics. *In vitro* and *in vivo* techniques get introduced face to face. The following basic techniques will get introduced: Genetic manipulation of microbial and eukaryotic cells (Purification of DNA, Use of DNA-modifying enzymes, gene cloning, PCR, mutagenesis, transformation, transfection, transduction); Genome editing (TALEN, ZFN, CRISPR); DNA sequence analysis (introduction of different systems, applications); quantification of gene expression (RT-qPCR, gene reporters systems, array techniques); protein analysis (immunological techniques, protein synthesis, covalent protein modification). In addition, methods for analysis of protein-DNA-interaction (EMSA, DNase I footprinting; interference footprinting, two-hybrid-systems, FRET) and bacterial and eukaryotic rDNA gene expression systems will be introduced. Further, up-to-date techniques in molecular biological medical diagnostics (flow cytometry, gendiagostic approaches, single cell characterization, molecular imaging and cytogenetics) will be explained and practiced.
Educational and qualification objectives	This module will help students to get ready to successfully realize the experimental program of their master work. By thoroughly learning and doing the students will acquire skills and techniques to stand-alone use biochemical, microbiological and molecular genetical methods. They will gain solid knowledge about molecular biological principals at the level of genomics, transcriptomics and proteomics in basic research

	and medical diagnostics.
Admission requirements for the module exam	protocols of experimental work and active contribution during seminars (presentation, report)
Requirements for the award of credit points (Weighting of grades in %)	Written examination in winter semester (30%), documentation of experimental work (15%), presentation during seminar (15%), oral examination in summer semester (40%).
Recommended literature	subject specific literature sources during lectures and seminars

Elective modules

Modulnummer	**MOLMED-S.17**
Modultitel	**Course for performers of animal experiments**
Modul-Verantwortlicher	Dr. S. Bischoff
Admission requirements for the module	None
Usability (required for)	Proof of qualification for participation in research projects with animal experiments
Type of module (obligatory, required elective, elective)	Elective module
Frequency of offer (Cycle)	Yearly
Duration of module	1 semester
Module composition / forms of instruction (lecture, exercise, seminar, practical training)	Lecture: 2 contact hours per week in winter semester (optional) Online-seminar: 20 h Practical work: 20 h in winter semester or summer semester
Credit points (ECTS credits)	-
Workload in: - Contact hours - Self-study (including exam preparation)	 68 h 30 h
Language of instruction	English
Content	The additional module provides the necessary knowledge and skills for qualified participation in an animal experiment in accordance with §7 TSG, §16TSchVersVO. To this end, the lecture "Animal Experimentation and Introduction to Bioethics" provides a deeper insight into the legal foundations and the resulting provisions and measures in the conduct of animal experiments. Furthermore, experimental animal science techniques, experimental design, an overview of experimental animals, disease models, knock out and transgenic mice, as well as the basics of bioethics including the 3R principle are taught. The successful completion of the online seminar confirms the required level of knowledge of the theoretical knowledge. This is a mandatory prerequisite for admission to participation in practical training with a final exam.
Educational and qualification objectives	Learning and qualification for qualified participation in an animal experiment according to §7 TierSchG and §16TSchVersVO
Most important molecular methods	No practical laboratory skills are needed.
Admission requirements for the module exam	The module examination consists of passing the final exam after the practical training
Requirements for the award of credit points (Weighting of grades in %)	There are no credit points awarded and no grading

Module Nr.	MOLMED-S.18
Module title	**Forensic Sciences**
Module supervisors	Prof. Dr. G. Mall / PD Dr. Frank Peters
Module requirements	none
Module usability	
Module type	compulsory optional module
Frequency (cycle)	annual
Module duration	2 semesters
Module composition / form of teaching	lecture: 1 SWS / seminar: 2 SWS practical training: 8 SWS
ECTS credits	
Presence hours Private study	165 h 240 h
Language	German
Content	The module conveys theoretical and practical knowledge in the following forensic fields: **1. Forensic Medicine** Introduction to the scope of activities of a forensic pathologist: Forensic medicine (legal inspection, forensic imaging, autopsy, histology, natural and non-natural causes of death) Principles of expertise (criminal or civil law) Clinical forensic medicine (victims of violence examinations) **2. Forensic Genetics** Examination of trace evidence (collection of evidence, preliminary testing, evidence analysis using autosomal STRs, X- and Y-chromosomal markers, trace examination, biometry, legal basics) Parental testing (biometry, legal basics) Mitochondrial DNA in the forensic context New developments (phenotyping, origin designation using gene expression, molecular age estimation) **3. Forensic/clinical Toxicology** Methodology of toxicological analysis (focus on mass spectrometry) Analysis and molecular impact mechanisms of alcohol and drugs (special consideration of new psychoactive substances) Clinical toxicology Postmortem toxicological analysis (focus on drug metabolism in bacteria and fungi)

	4. Forensic Entomology Forensically important insects Species determination using morphological and genetic methods Succession Estimation of the late post mortem interval **5. Forensic Biomechanics** Physical principles Probability calculation Injury causation (focus: penetrating/blunt force trauma, traffic accidents) Introduction to ballistics **6. Forensic Anthropology** Identification (personal effects, morphology, forensic odontostomatology, finger prints, molecular genetics, mass casualties) **7. Selected Criminalistics** Estimation of the early post mortem interval (changes to a after death, supravitality, body cooling, thanatochemistry) Blood stain pattern analysis
Learning and qualification targets	Students will be given an overview of the important forensic problems particularly within death investigations as well as deep insights in special fields. In the practical part students will be able to work on reality-based cases and topics with applied research. This will enable students to experience the workflow.
Most important (molecular) methods	PCR, Capillary electrophoresis, GC, HPLC, GC-MS, LC-MS, Histology, MKS-Simulation, FEM-Simulation
Requirement for module examination admission	Documented active participation, documented completion of one casework within the offered topics.
Requirement for credits	Oral examination, written scientific report
Recommended literature	Literature recommendations will be given at the beginning of the module.