Heinrich Heine Universität Düsseldorf

Module Handbook

Master of Science Programme

Molecular Biomedicine

Status: November 2023

Table of contents

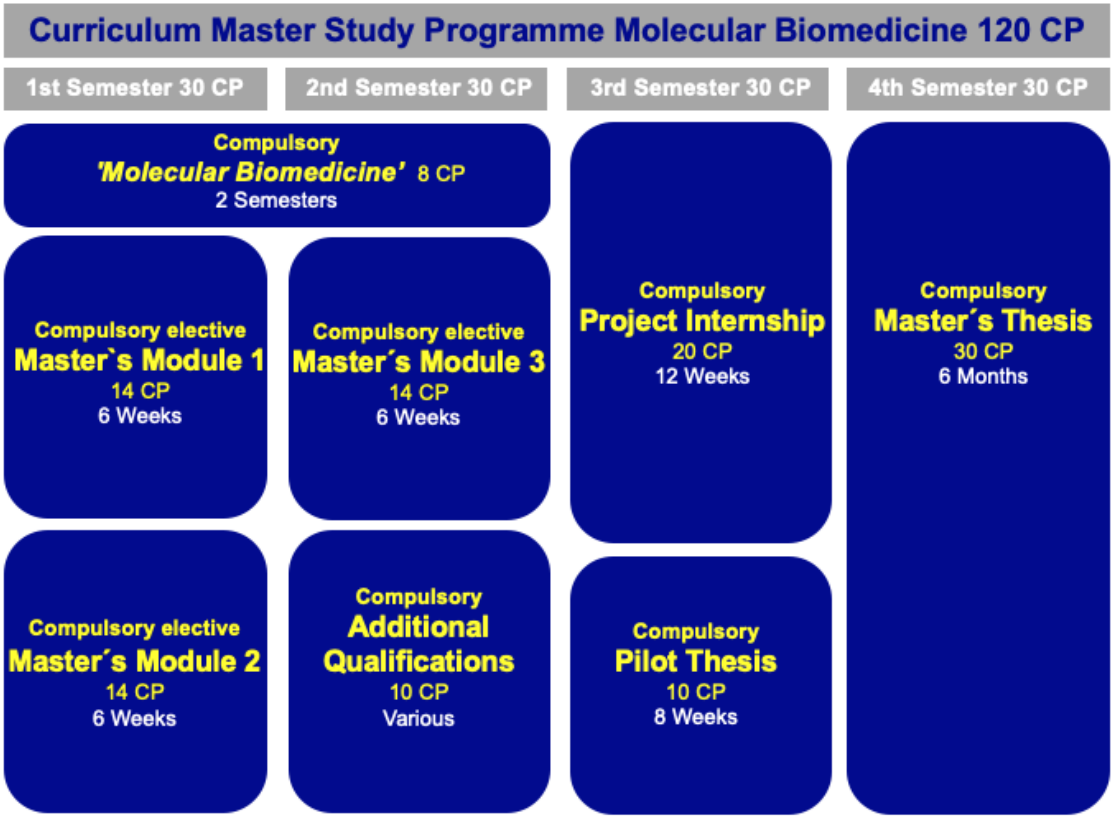

Fig. 1: Schematic study plan Master's programme Molecular Biomedicine; CP: Credit Points

"*Molecular Biomedicine*" (compulsory): Seminar; Duration: 2 semesters

Master's Modules 1 - 3 (compulsory elective): Three master's modules must be completed within the first two semesters. Two master's modules must belong to at least 2 different specialisation fields. The allocation of module places takes place centrally before the start of the studies.

Additional qualifications (compulsory elective): all freely selectable courses (i.e. lecture series, courses of the student academy, animal experimentation course, laboratory rotation, etc.)

Project Internship: Research internship (12 weeks, full-time); Also possible as a stay abroad

Pilot Thesis: Research internship (8 weeks, full-time); Preparation for the Master's thesis; with project outline

Master's Thesis: Preparation of an experimental work; Duration: 6 months

General information

The Master's programme Molecular Biomedicine is a research-oriented, interdisciplinary and interfacultary degree programme of the Faculty of Medicine and the Faculty of Mathematics and Natural Sciences. Other organisations involved are the German Diabetes Center (DDZ), the Leibniz Institute for Environmental Medicine Research (IUF) and Forschungszentrum Jülich (FZ Jülich).

Lectures and examinations take place in German, some courses are also offered in English. Subject-specific publications are usually only available in English. English language skills acquired as part of school education at a secondary school are therefore required.

At the beginning of the 1st semester, there is the compulsory module "Molecular Biomedicine". This compulsory module lasts two semesters and creates a uniform basis for graduates from various bachelor's degree programmes. In the further course of study, three elective master's modules follow.

The master's modules are assigned to four different specialisation fields:

Specialisation field A: Cell & organ biology (oncology, neurobiology, genetics, environmental & aging research)
Specialisation field B: Immunology, infectiology, inflammation & stem cell biology
Specialisation field C: Metabolism, metabolic and cardiovascular diseases
Specialisation field D: Bioinformatics, structure & diagnostics

In order to ensure a certain breadth in the training, at least 2 master's modules from different specialisation fields must be taken (an overview of the respective compulsory elective modules of the individual specialisation fields is shown in table 1).

The compulsory module "Additional Qualifications" concludes the 2nd semester. Depending on their needs, students acquire additional qualifications in freely accessible courses and classes at HHU Düsseldorf. These include also courses and workshops of the Student Academy (Studierendenakademie) and the Central Institution for Animal Research and Scientific Animal Welfare Tasks (ZETT). Optionally, additional qualifications can be combined with a laboratory rotation.

In the 3rd semester, students complete 2 research internships: A 12-week project internship (Projektpraktikum) followed by an 8-week pilot project (Pilotarbeit).

In the project internship, students are entrusted with a research project, which they work on under direct supervision.

The pilot thesis is also a research internship and serves as a prelude to the master's thesis. At the end of the pilot thesis, students draft a concept for their master's thesis and draft a project outline.

A stay abroad at a cooperating research institute or at a research institute of student´s own choice is ideal for these study phases.

In the 4th semester, students write an experimental master's thesis (6 months) in the field of molecular biomedicine.

Rules for the allocation of places for Master's modules I to III

Module places are allocated centrally by the coordinator of the degree programme. Before the start of the 1st semester, 3 master's modules are chosen via a compulsory elective form, stating the first, second and third choices. If a master's module is overcrowded, the decision is made by drawing lots. Due to the limited availability of module places per academic year, 3 master's modules must be completed within the first year of study. Out of consideration for the first-year students of the following academic year, the allocation of module places is otherwise subordinate.

Table 1: Compulsory elective modules of the 4 specialisation fields with module places and time slots

Module	Lecturers	Places	Time slots*		
			WS		SS
			I	II	III
(A) Cell & organ biology (oncology, neurobiology, genetics, environmental & aging research)					
M1510 Signal transduction of the cell: Molec. mechanisms of stress response (apoptosis, autophagy, senecescence)	Wesselborg	10		10	
M1520 Molecular oncology I	Mahotka	12	12		
M1540 Environmentally-induced signalling processes	Haendeler	3			3
M1560 From DNA to variety of shapes	Beye	3	3		
M1570 Receptors as target molecules in biomedicine	Prömel	8		8	
M1580 Molecular oncology II	Mahotka	10			10
M1590 Pathophysiology of the nervous system	Berndt	6	6		
(B) Immunology, infectiology, inflammation & stem cell biology					
M2520 Molecular virology and structural biology	N.N.I	4	2		2
M2530 Molecular medical immunology	Uhrberg	8			8
M2540 Immunology & host-pathogen interaction	Esser	4			4
M2570 Stem cell biology & tissue regeneration	Adjaye	16		8	8
M2580 Immunological principles of viral infection	Lang	4			4
(C) Metabolism, Metabolic and Cardiovascular Diseases					
M3510 Molecular biomedicine of inner organs	Lammert	20	20		
M3520 Cardiovascular biology	Elvers	8			8
M3530 Insulin resistance and diabetes mellitus	Al-Hasani	6		6	
M3540 Evolution and biochemistry of organelles	Martin	3		3	
M3560 Molecular pharmacology & biotechnology	Cortese-Krott	6		6	
(D) Bioinformatics, structure & diagnostics					
M4560 Genome analysis in biomedical research	Martin	20	20		
M4520 Conformation, misfolding & aggregation of biol. macromolecules: from Alzheimer's to Parkinson's	Willbold	8		8	
M4530 Structural biology: Convolution, misfolding & aggregation in high resolution	Willbold	8			8
M4540 Molecular diagnostics	Mahotka	6		6	
Sum		**173**	**63**	**55**	**55**

***Time slots:** One module should be taken from each time slot if possible; WS: winter term; SS: summer term

I	1st half of the semester in WS
II	2nd half of the semester + semester break in WS
III	1st + 2nd half of the semester in SS

1100 Molecular biomedicine (compulsory)

Molekulare Biomedizin (Pflicht)

Module convenor
Prof Sebastian Wesselborg (sebastian.wesselborg@uni-duesseldorf.de) and Prof Dr Philipp Lang (langp@uni-duesseldorf.de)

Lecturers
Prof Sebastian Wesselborg, Prof Heiner Fangerau, Prof Björn Stork, PD Dr Csaba Mahotka**,** Prof (apl.) Joachim Altschmied, Prof J. Haendeler, Prof Martin Beye, Prof Philipp Lang, Dr Haifeng Xu, Dr Aleksandra Pandyra, Dr Gabriel Leprivier, Dr Carsten Münk, Dr Sören Twarock, Prof Kai Stühler, Prof Markus Uhrberg, Prof (apl.) Charlotte Esser, Prof Gesine Kögler, Prof Martin Beye, Prof Eckhard Lammert, Prof Margitta Elvers**,** Prof Maria Grandoch, Prof Hadi Al-Hasani**,** Prof William F. Martin**,** Prof Dieter Willbold, Prof Simone Prömel, Dr Christian Dumpitak

Module organisation
Prof Dr Philipp Lang (langp@uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
240 hrs	8 CP	52 hrs	188 hrs	2 Semesters

Courses	Frequency of offer	Group size
Lecture/Seminar: 2 PPW	Winter term	40 Students

Learning outcomes/competences
After attending the this 2-semester lasting module, students are able to name the fundamentals of molecular medicine and their current research areas. They can describe the fundamentals of good scientific practice, HHU's research data guideline and ethical principles for research involving humans. They can search for literature and present a method of biomedical research or a publication on current research areas in an appropriate form in English. They are able to deepen and increase their knowledge by self-study of selected topics in the field of molecular medicine, statistics and further topics by e-learning contents.

Forms of teaching
Lecture, seminar, e-learning with self-assessment tests in ILIAS

Contents
In the lecture, basics and in-depth knowledge in cell & organ biology (oncology, neurobiology, genetics, environment & aging research), infectiology, immunology, damage & regeneration, metabolism, metabolic and cardiovascular diseases, bioinformatics, structure & diagnostics will be taught. The lecture also deals with research ethics with a focus on research involving humans. Furthermore, good scientific practice and the research data guideline of HHU are taught. Following the lecture, students will talk about selected biomedical methods. The presentations will be held in English. The classroom teaching is supplemented by extensive e-learning units in the field of molecular medicine, statistics and further topics. Students deepen and broaden their knowledge by self-study of selected topics in the field of molecular medicine, statistics and further topics by e-learning offers in ILIAS. They will test their knowledge gain by mandatory self-assessment tests in ILIAS.

Prerequisites
Formal: Admission to Master´s programme Molecular Biomedicine; English proficiency
Content: Basic knowledge of the structure and function of eukaryotic cells; General knowledge of cell biology

Type of examination
Presentation, ungraded; Duration: 15 minutes

Prerequisites for the award of credit points
(1) Presentation of a method or publication in the seminar
(2) Regular participation in the seminar

(3) Completion of self-assessment tests for e-learning in ILIAS; Duration: 26 hrs in total (5 minutes/question, approx. 310 questions)
Assignment to specialisation field
Module applicability in other study courses Non
Assessment The module is ungraded.
Language of instruction German and English
Further information Compulsory module with compulsory attendance; Module duration 2 semesters; Attendance at the preliminary meeting is mandatory. Lecture dates "Statistics in the Life Sciences" (online lecture via video conference): 16. – 20.10.23: 11 a.m. and on Tuesday, 17.10.23 also at 1 p.m.; If students have a Master's module at the specified times, the recorded lectures can be streamed in ILIAS as "video on demand" at a later date. There is a deadline for successfully passing the self-assessment tests in ILIAS: 15th November 2023 (Statistics) and July 15th 2024 (Molecular Medicine)

M1510 Cellular signal transduction: Molecular mechanisms of stress response (apoptosis, autophagy, senescence)

Signaltransduktion der Zelle: Molekulare Mechanismen der Stressantwort (Apoptose, Autophagie, Seneszenz)

Module convenor
Prof Sebastian Wesselborg (sebastian.wesselborg@uni-duesseldorf.de)

Lecturers
Prof Dr Sebastian Wesselborg, Prof Dr Björn Stork**,** Dr Dennis Sohn, Prof Dr Andreas Reichert**,** Prof Dr Christoph Suschek, PD Dr Carsten Berndt**,** further lecturers and staff

Module organisation
Prof Dr Björn Stork (bjoern.stork@uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses		Frequency of offer	Group size
Practical Course:	18.0 PPW	Winter term	10 Students
Lecture:	1.5 PPW		
Seminar:	0.5 PPW		

Learning Outcomes /Competences
In this course series, the lecture gives students a comprehensive overview of the various signal transduction processes in the cell as well as the medical relevance of these processes. The practical course focuses on signal transduction of apoptosis, autophagy, ferroptosis, senescence, mitochondrial quality control, NF-κB and NFAT signalling and nitric oxide (NO)/redox signalling. The students will be able to apply the corresponding analysis methods and interpret the corresponding results.

Forms of teaching
Lecture, literature seminar, practical course, presentations

Contents
Lecture:
Overview of the mechanisms of cellular signal transduction:
apoptosis; clearance of apoptotic cells; Autophagy; cell cycle and proliferation; cell aging (senescence) and the role of p53 and p21; TNF receptor and NF-κB signalling; mode of action of immunosuppressants and FK506, NFAT and calcineurin signalling; Nitric oxide (NO) signalling, mitochondrial quality control, mitophagy, cellular respiration (oxidative phosphorylation), iron and ferroptosis, oxidative damage, thiol redox signalling

Literature seminar:
In the literature seminar, the understanding of the methodological approach to the acquisition of scientific findings is to be conveyed. The students learn to familiarize themselves with the respective specialist literature, which is necessary to understand a publication to be presented. The required literature is provided by the lecturers.

Practical course:
Content:

- Flow cytometric detection of DNA degradation during apoptosis (FACS)
- Caspase and PARP cleavage during apoptosis (Western blot)
- Detektion der LC3-Lipidierung zum Nachweis der Autophagie (Western blot)
- LC3 immunofluorescence for the detection of autophagy (fluorescence microscopy)
- Flow cytometric detection of mCitrine-LC3 degradation during autophagy (FACS)
- β-galactosidase staining to detect senescence (microscopy)
- Quantification of cell cycle arrest by staining nuclear DNA content (FACS)
- Detection of DNA damage response by p53/p21 analysis in Western blot

- NF-κB activation (reporter assay)
- NFAT activation (reporter assay)
- Determination of mitophagy by fluorescence microscopy
- Irradiation of cells with UVA
- Determination of protection against UVA-induced apoptosis by arginine/iNOS metabolism
- Activation of iNOS by pro-inflammatory cytokines
- Quantification of iNOS expression and correlation to UVA-induced apoptosis
- Quantitative evidence of an increase in systemic NO derivative concentration due to ingestion of nitrite/nitrate-containing foods
- Detection of the redox status of proteins and certain oxidative thiol modifications (Western blot, redox shift)
- Detection of oxidative damage to DNA and lipids (FACS, dot blots, fluorescence microscopy)

Techniques:

- Cultivation of eukaryotic cells (sterile work), cell count determination, cell stimulation and cell lysis
- Flow cytometry (LSR Fortessa by BD)
- Quantitative protein determination, SDS-PAGE, Western blot
- Fluorimetric / colorimetric assays
- Microscopy
- Transfection, reporter assays
- Protein crystallisation
- Chemiluminescence detection (CLD) of nitric oxide and its derivatives
- Fluorescence-based detection of reactive oxygen and nitric oxide species
- Immunocyto- and immunohistochemical working methods
- Culture of yeast cells
- Fluorescence-based techniques
- ATPase assays

Prerequisites

Formal: Admission to the Master's programme Molecular Biomedicine

Content: Basic knowledge of the structure and function of eukaryotic cells; General knowledge of cell biology; Principles and mechanisms of signal transduction

Type of examination

(1) Competence area knowledge (80% of the grade): Written examination of the contents of the lecture and the practical course; Duration: 60 minutes

(2) Competence area documentation (20% of the grade): Presentation about the experiments of the practical course; Duration: 15 minutes and 5 minutes discussion

Requirements for awarding credit points

(1) Regular and active participation in the internship

(2) Giving two presentations (preferably in English):

a) Presentation of the internship experiments in a presentation (Duration: 15 minutes and 5 minutes Discussion)

b) Literature seminar with presentation of an original publication (Duration: 15 minutes and 5 minutes Discussion)

(3) Passing the final exam consisting of the contents of the lecture and the practical course

Assignment to specialisation field

A) Cell & organ biology

Module applicability in other study courses

None

Assessment

The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction German and English (As a rule, students should hold the literature seminar and the presentation of the results of the practical part in English)
Other information The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M1520 Molecular oncology I

Molekulare Onkologie I

Module convenor
PD Dr Csaba Mahotka (mahotka@med.uni-duesseldorf.de)

Lecturers
Prof Jürgen Scheller, Dr Roland Piekorz, Dr Michèle Hoffmann, Prof Hans Neubauer, PD Dr Csaba Mahotka, Prof Dr med Dagmar Wieczorek, Prof Dr med Nikolas H. Stoecklein, Prof Dr D. Nettersheim, Dr D. Floss, PD Dr KL Schäfer, Dr B. Behrens, Dr B. Hildebrandt, Prof Dr H. Rieder, Dr Dietzel-Dahmen, Dr D. Niederacher, further lecturers and staff members

Module organisation
PD Dr Csaba Mahotka (mahotka@med.uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Winter term	12 Students

Learning outcomes/competences
Students can name essential criteria in the classification of human tumours. They can describe characteristic characteristics of tumours and tumour cells.
They can describe exemplary mechanisms in chemical, physical and biological carcinogenesis and compare protective mechanisms, especially DNA repair systems.
They can explain the inheritance modes of hereditary tumour syndromes and indicate the principal genetic and epigenetic mutation types, including chromosomal aberrations.
They can list important oncogenes and tumour suppressor genes and explain their effect and interaction by way of example. They can assign the products of these genes to signal transduction pathways and cellular regulatory systems.
They can enumerate the individual steps in the spread of malignant tumours, indicate important molecules and factors in stromal tumour cell interaction, invasion and metastasis, and interpret their function in these processes.
Students can specify suitable methods for analyzing the typical characteristics of tumour cells. You can perform and evaluate important methods.
Students can specify suitable methods for the analysis of the typical genetic and epigenetic changes of tumour cells. They can extract nucleic acids and proteins from tumour tissues and tumour cell lines and assess their quality and suitability for further analysis. They can perform and evaluate important methods (i.e. PCR, RT-PCR, MS-PCR, mutation detection, Western blot). They can generally assess the areas of application and suitability of the methods for the analysis of tumours.
The students can describe the aim, implementation and results of the experiments carried out clearly and in scientifically adequate language and form and present the interpretation of the results.
Students use the learned basic terms of clinical and molecular oncology and molecular and cell biological analysis safely and appropriately in oral and written communication and documentation. They can act according to written and oral test instructions and supplement missing information with queries or written sources. You can find suitable scientific literature on general and specific questions in the field of tumour biology and extract information from databases.

Contents
Lecture: General Tumour Biology
properties of tumours and tumour cells; classification and epidemiology of human tumours; mechanisms of carcinogenesis; DNA repair; genetics and heredity mechanisms in hereditary tumours; Chromosomal

changes in tumours; mutation types and mutation effects; tumour suppressor genes; cell cycle regulation and checkpoints; apoptosis and senescence; viral and cellular oncogenes; growth factors and receptors; signal transduction pathways in tumours; multi-step carcinogenesis; mechanisms of invasion and metastasis; hypoxia regulation and angiogenesis; Tumour epigenetics
Biology of selected tumours. Chronic myeloid leukemia; Acute myeloid leukemias; Burkitt's lymphomas and B-cell lymphomas; Wilm's tumour; Colorectal carcinoma (MSI and CIN type with hereditary syndromes); breast cancer (molecular subtypes and targeted tumour therapy); renal cell carcinoma (clear cell and papillary); Prostate cancer, recessively inherited tumour syndromes (ataxia telangiectasia, xeroderma pigmentosum).
Practical course:
Extraction of DNA and RNA from cell lines and paraffin with quality control, mutation analysis from DNA and RNA by DHPLC and sequencing, microsatellite analysis; protein extraction from tumour cell lines, Western blot analysis; Qualitative and quantitative (real-time) PCR and RT-PCR, CRISPR/Cas methodology, analysis of DNA methylation by MS-PCR and pyrosequencing, cytology of tumour single cells, cytogenetic examination of tumour cells and cells from blood by chromosome banding and karyotyping as well as fluorescence in situ hybridisation, measurement of proliferation and cell cycle distribution of tumour cells under growth factor treatment; Bioinformatic analysis of gene sequences, mutations and chromosomal changes

Forms of teaching
Lecture with interactive parts (24 hours á 60 minutes)
Self study with e-learning materials and textbooks (110 hours)
Small group lessons (2 hours daily for 6 weeks)
Supervised laboratory internship in small groups (6 hours daily for 6 weeks)

Prerequisites
Formal: Admission to the Master's programme Molecular Biomedicine
Content: Solid basic knowledge of genetics, molecular and cell biology

Type of examination
(1) Competence area knowledge (80% of the grade): Written examination on the contents of the lecture and the practical course; Duration: 90 minutes
(2) Competence area documentation (20% of the grade): Protocol attestation experiments; Duration: 5 - 10 minutes at the end of each module part (6 module parts)

Requirements for award of credit points
(1) Regular and active participation in the internship;
(2) Passing the exam and the protocol attestation on experiments

Assignment to specialisation field
A) Cell & organ biology

Module applicability in other study courses
None

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German and English

Further information
The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M1540 Environmentally induced signalling processes in mammalian cells and *Caenorhabditis elegans*

Umweltinduzierte Signalprozesse in Säugerzellen und *Caenorhabditis elegans*

Module convenor
Prof Dr Joachim Altschmied (Joachim.Altschmied@uni-duesseldorf.de), Univ.-Prof Dr Judith Haendeler (juhae001@uni-duesseldorf.de)

Lecturers
Prof Dr Joachim Altschmied**,** Univ. Prof Dr Judith Haendeler**,** PD Dr Klaus Unfried**,** Dr Thomas Haarmann-Stemmann**,** further lecturers and staff members

Module organisation
Dr Sascha Jakob (sascha.jakob@uni-duesseldorf.de)

Work load	**Credit points**	**Contact time**	**Self study**	**Duration**
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	**Frequency of offer**	**Group size**
Practical course: 18 PPW Lecture: 2 PPW	Summer term	max. 3

Learning outcomes/competences
The module aims to develop signal transduction mechanisms in response to environmental signals in mammalian cells and C. *elegans* at the cellular level and in an animal model as well as a selection of experimental techniques to investigate these processes. The participants should be able to present and explain the theoretical background and interpret the experimentally collected findings based on this. In addition, the methods developed should be able to be transferred to other questions with regard to research-oriented work. Due to the small number of participants, intensive support is guaranteed.

Forms of teaching
Practical courses, accompanying lecture
Practical course with independent experimental execution in groups of two

Contents
The response of cells and organisms to external signals plays a central role in many physiological and pathophysiological situations. This module discusses basic mechanisms of signal transduction in mammals and the nematode *C. elegans* in response to environmental influences. The focus is on mitochondria, membrane and transcription changes as well as adaptation reactions of an entire organism. Corresponding experiments with state-of-the-art methods are carried out on these topics.
Lecture:
The practical course is accompanied by a daily one-hour lecture, in which the theoretical background (membrane-bound and cytosolic receptors, mitochondria, signalling cascades, transcription factors, cell proliferation, cell migration, apoptosis, *C. elegans*) and techniques for the molecular and cell biological as well as biochemical analysis of these processes and the molecules involved in mammals and nematodes are taught.
Practical course:
In the practical part, which is carried out in groups of two, a wide range of modern experimental methods for the analysis of signal transduction processes and cellular responses to external stimuli and for the stress adaptation of *C. elegans* is taught. Emphasis is placed on a high degree of "hands-on-time" as preparation for practical laboratory work as part of a master's thesis (entrance and abbot). Furthermore, the test execution must be documented in a protocol, which should be submitted promptly.
The module is divided into four main topics, which are carried out by four different working groups of the IUF: Mitochondria in signal transduction (AG Haendeler), membrane-dependent signal transduction (AG Unfried), AhR signalling (AG Haarmann-Stemmann) and stress responses in *C. elegans* (AG Ventura).

Prerequisites
Formal: Bachelor's degree in biology or a closely related subject with sufficient teaching content in biological fields and acceptance for one of the master's programs Biology, Biology International or Molecular Biomedicine at HHU Düsseldorf

Content:	Sound basics of cell biology, principles of gene regulation and signal transduction, basic biochemical knowledge

Type of examination

(1) Competence area knowledge (50% of the grade): Oral examination on the contents of the lecture and the practical course; Duration: 30 - 60 minutes
(2) Competence area documentation (25% of the grade): Protocol with evaluation and discussion of the experiments carried out; Length of the protocol: Approx. 60 pages
(3) Competence area planning and execution of practical experiments (25% of the grade): Daily attestation before and after individual experiments; Duration: about 5 minutes daily

Prerequisites for the award of credit points

(1) Regular participation in the practical course (maximum 2 days of absence)
(2) Submission of a protocol that meets the requirements of scientific documentation
(3) Passing the final examination in the competence area knowledge

Assignment to specialisation field

A) Cell & organ biology

Module applicability in other study courses

Master's programme Biochemistry and Biology

Assessment

The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction

German and English

Further information

The module is assigned centrally. Attendance at preliminary meeting is mandatory.

M1560 From DNA to diversity

Von der DNA zur Formenvielfalt

Module convenor
Prof Dr Martin Beye

Lecturers
Prof Dr Martin Beye, Prof Dr Laura Rose

Module organisation
Prof Dr Martin Beye (Martin.Beye@uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Winter term	3 Students

Learning outcomes/competences
Students learn to analyse gene regions and gene families bioinformatically and experimentally. Project-related evolutionary biological questions are developed, which the students test functionally using molecular genetical and computer-based methods.

Students learn how to use gene databases (NCBI, miRBase) and how to create phylogenies. In the lecture the basics of gene changes and their significance for the diversity of forms in the animal and plant kingdoms will be taught. Students also learn the basics of the plant immune system with a focus on regulating the system.

Contents
Lecture:
How do new characteristics evolve (i.e. blueprints, resistance to pathogens)? How are these new traits achieved by regulatory and functional changes in genes? Which evolutionary mechanisms are responsible for this? Experimental implementation of genetic and evolutionary questions. Teaching of molecular methods, population genetic concepts, modelling and statistical procedures.

Practical course:

AG Beye: How is innate social behavior specified? How does this behavior develop in the course of evolution? The *fruitless* gene is part of the sex-determining cascade of the bee and is spliced according to sex. Based on the gene, we will deal with the question of how innate behaviors are specified in development. Molecular genetic techniques such as cloning, sequence analysis, sequence comparisons and whole-mount immunostaining are used to describe anatomical and molecular causes in the organism. In addition, behavioral data of a mutant are analyzed and statistically evaluated in the course. Questions are developed in the course with the aim of presenting molecular and anatomical causes of innate behavior.

AG Rose: The miR482 superfamily, a diverse family of microRNAs at the sequence level, regulates parts of the plants' immune system. As part of the molecular arms race between pathogen and plants, the miR482 family is exposed to constant selection pressure. The gene family is examined at the sequence level (i.e. DNA extraction of various plants, cloning of family members in E. coli, sequencing, creation of a phylogeny and a regulatory network) as well as for expression changes when the cultivated tomato is infected with a pathogen (infection assay, RNA extraction, cDNA synthesis, PCR, qPCR). In addition to the analysis of this pathogenic interaction, we morphologically characterize the microbiome of various crops, i.e. we create an overview of the totality of associated microorganisms of these crops.

Seminar:

Lecture series on current methods and results of molecular and evolutionary genetics with a focus on the immune system of the plant, the microbiome, various pathogens (i.e. *P. infestans*) and the Solanaceae (nightshade family).
Prerequisites **Formal:** Admission to master´s programme **Content:** Basic knowledge of molecular genetics is expected.
Type of examination: (1) Competence area knowledge (60 % of grade): Written examination (as a rule) on the contents of the lecture and the practical course; Duration: 120 minutes (2) Competence area documentation (30% of the grade): Protocol (topic, implementation, evaluation and discussion of scientific experiments); Volume: approx. 30 - 40 pages (including appendix, figures and tables) (3) Area of competence scientific presentation (10% of the grade): Presentation (development of the material, graphic representation of the contents, lecture, discussion); Duration: 30 minutes
Requirements for award of credit points (1) Passing the competence area knowledge (2) Regular and active participation in the practical course (3) Submission of a protocol that meets the requirements of scientific documentation
Assignment to specialisation field A) Cell & organ biology
Verwendung des Moduls (in anderen Studiengängen) Master Biology
Assessment The grade is weighted according to the credit points (CP) in the overall grade: MSc Molecular Biomedicine 14/72 CP.
Language of instruction German and English
Further information The module is assigned centrally. Attendance at preliminary meeting is mandatory.

M1570 Receptors as target molecules in biomedicine

Rezeptoren als Zielmoleküle in der Biomedizin

Module convenor
Prof Dr Simone Prömel (proemel@hhu.de)

Lecturers
Prof Dr Simone Prömel, Victoria Groß, further lecturers and staff members

Module organisation
Prof Dr Simone Prömel (proemel@hhu.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Winter term	8 Students

Learning outcomes/competences
Students are able to describe and apply the basic concepts of receptor biology and corresponding signalling pathways. They know the function of signalling pathways in different biological contexts and organs and the role of these organs, for example in metabolism. Furthermore, they are able to explain the (patho-)physiological relevance of receptor signalling pathways and to describe the effect of mutations and modulators (agonists, antagonists, etc.).
The students can practically apply the acquired methodological knowledge to various receptors. They are able to independently carry out and plan molecular and cell biological experiments for the analysis of receptor functions and their modulation. Students learn the independent and precise handling of modern laboratory equipment and apparatus from the molecular and cell biological field, such as PCR machines, sterile cabinets, microscopes, incubators, multimode microplate readers. They can document the experiments carried out and evaluate, present and interpret the results obtained according to scientific standards.
The students are able to independently develop a given topic with the help of appropriate specialist literature in English and to present it comprehensibly.

Forms of teaching
Lecture, practical course, seminar

Contents
Lecture:

- Receptor types, their signalling cascades and their function in different processes
- The relevance of receptors in the essential organs of metabolism: Liver, pancreas, fat, brain; Biochemical basis and functions of these organs
- The role of receptors in different diseases and the importance of their modulation for therapeutic approaches
- Receptor-agonist interactions, antagonists, kinetics
- Receptor pharmacology, drug mechanisms, principles of a compound screen
- Properties of receptors as therapeutic targets
- Methods of investigation of receptors and modulation of receptors

Practical course:

- Analyses of the expression of receptors (in cell culture and tissue)
- Investigation of signal transduction of receptors using the example of different therapeutically relevant GPCRs (basal activity, activity after stimulation**,** measurement of intracellular signals, concentration-response curves, determination of EC50 values and evaluation)
- Characterisation of receptor-ligand bonds (using BRET analyses)
- Cloning and testing of clinically relevant GPCR variants (expression, reporter gene and *second messenger* assays)

- Investigation of the effect of different modulators on the expression, function and signals of receptors using the example of different GPCRs
- Characterisation of the effect of GPCR mutations on physiological processes

Seminar:
The students will prepare a seminar lecture on selected original scientific publications on various topics of receptor biology and its application, give it to the group and discuss it afterwards.

Prerequisites
Formal: Admission to master's programme
Content: Basic knowledge of cell and molecular biology

Type of examination
1. Area of competence knowledge (60% of grade): Written examination (as a rule) on the contents of the lecture and the practical course; Duration: 90 minutes
2. Area of competence documentation (20% of the grade): Preparation of a protocol for the practical course (topic, implementation, evaluation and discussion); Approximately 20 pages
3. Area of competence scientific presentation (20% of the grade): Seminar lecture (development of the material, presentation of the contents, lecture and discussion); Duration: 20 minutes

Prerequisites for the award of credit points
(1) Passing the module exam
(2) Regular and active participation in the Practical course
(3) Submission of a protocol that meets the requirements of scientific documentation
(4) Participation in the seminar and presentation of a seminar lecture

Assignment to specialisation field
A) Cell & organ biology

Module applicability in other study courses
Master Biology

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German and English

Further information
The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M1580 Molecular Oncology II

Molekulare Onkologie I

Module convenor
PD Dr Csaba Mahotka (mahotka@med.uni-duesseldorf.de)

Lecturers
Dr Mayo Röttger, Dr Roland Piekorz, PD Dr Michèle Hoffmann, Prof Hans Neubauer, PD Dr Csaba Mahotka, Prof Dr med. Nikolas H. Stoecklein, Prof Dr Daniel Nettersheim, PD Dr Doreen Floss, PD Dr Karl Ludwig Schäfer, Dr Bianca Behrens, Dr Dieter Niederacher, Dr Gabriel Leprivier, PD Dr Edgar Grinstein, Prof Christoph Suschek, Dr Vera Grotheer, Dr Margaretha Skowron, Prof Miriam Cortese-Krott, and further lecturers and staff members

Module organisation
PD Dr Csaba Mahotka (mahotka@med.uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Summer term	10 Students

Learning outcomes/competences
Students can name essential criteria in the classification of human tumours. They can describe characteristic features of tumours and tumour cells.
They can describe exemplary mechanisms in chemical, physical and biological carcinogenesis and compare protective mechanisms, especially DNA repair systems.
They can explain the inheritance modes of hereditary tumour syndromes and indicate the principal genetic and epigenetic mutation types, including chromosomal aberrations.
They can list important oncogenes and tumour suppressor genes and explain their effect and interaction by way of example. They can assign the products of these genes to signal transduction pathways and cellular regulatory systems.
They can enumerate the individual steps in the spread of malignant tumours, indicate important molecules and factors in stromal tumour cell interaction, invasion and metastasis, and interpret their function in these processes.
Students can specify suitable methods for analyzing the typical characteristics of tumour cells. They can perform and evaluate important methods.
Students can specify suitable methods for the analysis of the typical genetic and epigenetic changes of tumour cells. They can extract nucleic acids and proteins from tumour tissues and tumour cell lines and assess their quality and suitability for further analysis. They can perform and evaluate important methods (i.e. PCR, RT-PCR, MS-PCR, mutation detection, Western blot). They can generally assess the areas of application and suitability of the methods for the analysis of tumours. Students can use biological databases, understand how algorithms work, apply the structure of programming languages to query data. The students can describe the aim, implementation and results of the experiments carried out clearly and in scientifically adequate language and form and present the interpretation of the results.
Students use the learned basic terms of clinical and molecular oncology and molecular and cell biological analysis safely and appropriately in oral and written communication and documentation. They can act according to written and oral test instructions and supplement missing information with queries or written sources. You can find suitable scientific literature on general and specific questions in the field of tumour biology and extract information from databases.

Contents
Lecture: General tumour biology

Properties of tumours and tumour cells; classification and epidemiology of human tumours; mechanisms of carcinogenesis; DNA repair; genetics and heredity mechanisms in hereditary tumours; Chromosomal changes in tumours; mutation types and mutation effects; tumour suppressor genes; cell cycle regulation and checkpoints; apoptosis and senescence; viral and cellular oncogenes; growth factors and receptors; signal transduction pathways in tumours; multi-step carcinogenesis; mechanisms of invasion and metastasis; hypoxia regulation and angiogenesis; Tumour epigenetics
Biology of selected tumours. colorectal cancer (MSI and CIN type with hereditary syndromes); breast cancer (molecular subtypes and targeted tumour therapy); renal cell carcinoma (clear cell and papillary); Prostate cancer. Bioinformatics (databases, programming languages, algorithms, etc.).
Practical course:
Extraction of DNA and RNA from cell lines and paraffin with quality control, mutation analysis from DNA and RNA by DHPLC and sequencing, microsatellite analysis; protein extraction from tumour cell lines, Western blot analysis; Qualitative and quantitative (real-time) PCR and RT-PCR, analysis of DNA methylation by MS-PCR and pyrosequencing, cytology of tumour single cells, measurement of proliferation and cell cycle distribution of tumour cells under growth factor treatment; Bioinformatic analysis of gene sequences, mutations and chromosomal changes; Biological databases, sequence comparisons and significance, homology search, multiple sequence alignment and reliability, sequence file formats and their fields of application (i.e. FASTA, GFF, VCF, gVCF, SAM/BAM); determination of the pathogenic potential of DNA variants using bioinformatic methods; In silico primer design to optimize Amplikon signature in High-Resolution Melting (HRM) analyses.

Forms of teaching
Lecture with interactive parts (24 hours á 60 minutes)
Self study with e-learning materials and textbooks (110 hours)
Small group lessons (2 hours daily for 6 weeks)
Supervised laboratory practical course in small groups (6 hrs daily for 6 weeks)

Prerequisites
Formal: Admission to Master´s programme Molecular Biomedicine
Content: Solid basic knowledge of genetics, molecular and cell biology

Type of examination
(1) Competence area knowledge (80% of the grade): Written examination on the contents of the lecture and the practical course; Duration: 90 minutes
(2) Competence area documentation (20% of the grade): Protocol attestation experiments; Duration: 5 - 10 minutes at the end of each module part (5 module parts)

Requirements for award of credit points
(1) Regular and active participation in the Practical course;
(2) Passing the exam and the protocol attestation on experiments

Assignment to specialisation field
A) Cell & organ biology

Module applicability in other study courses
None

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German and English

Further information
The module is assigned centrally. Attendance at an arranged preliminary meeting is mandatory.

M1590 Pathophysiology of the nervous system

Pathophysiologie des Nervensystems

Module convenor
PD. Dr. Carsten Berndt (berndt@hhu.de)

Lecturers
Mitarbeiter/innen der Klinik für Neurologie

Module organisation
PD Dr Csaba Mahotka (mahotka@med.uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Winter term	6 Students

Learning outcomes/competences
Students can name the cell types of the brain and their functions. They can describe common and different molecular bases of many diseases of the central and peripheral nervous system, they know corresponding cell and animal models, as well as the symptoms of the diseases. Students can also name treatment options and know which legal and ethical regulations must be observed in clinical trials. They can reproduce the theoretical foundations of various in *vitro*, *ex vivo* and *in vivo* methods for researching the pathophysiology of the nervous system. In addition, students can present scientific results to an audience.

The students are also able to carry out these methods in practice and to independently carry out molecular and cell biological as well as biochemical experiments for the analysis of pathophysiological processes and signaling pathways in cells of the nervous system. Students learn how to use modern laboratory equipment and apparatus independently and precisely, such as PCR machines, gel apparatus, FACS devices, electrophysiology setups, sterile workbenches, microscopes, or plate readers.

They can document the experiments carried out as well as evaluate and interpret the results obtained according to scientific standards and present them as a scientific poster. They can also discuss and defend results.

Contents
Lecture:
1. Cell types of the nervous system and their functions
2. Redox regulation/oxidative stress
3. Fundamentals of immunology and neuroinflammation
4. Multiple sclerosis, stroke, epilepsy, encephalitis, myasthenia gravis, Parkinson's disease
5. Experimental (animal) models of multiple sclerosis, stroke and other diseases
6. Study Coordination and Biobanking

Practicals:
1. Integration/insight into current research projects
2. Isolation and cultivation of different cell types
3. Investigation of relevant cellular processes in the pathophysiology of the nervous system such as migration and activation of immune cells, de- and remyelination by oligodendrocytes, or differentiation of stem and progenitor cells
4. Photothrombosis as a stroke model in mice, optical coherence tomography and optical character recognition as a readout in neuroinflammation in mice
5. Attending clinic consultations and meeting patients

Seminar:
The students are introduced to the evaluation, presentation and presentation of scientific data. The students create a poster with parts of their data and present it as if they were at a conference. In addition, students learn about certain aspects of the pathophysiology of the nervous system and defend them in discussion groups.

Forms of teaching
Lecture, Practicals, Seminar

Prerequisites
Formal: Admission to Master´s programme Molecular Biomedicine
Content: Basic knowledge of practical laboratory work, interest in the nervous system and translational research, an animal experiment certificate would be advantageousBasic knowledge of practical laboratory work, interest in the nervous system and translational research, an animal experiment certificate would be advantageous

Type of examination
(1) Competence area knowledge (75% of the grade): Written examination on the contents of the lecture and the practical course; Duration: 90 minutes
(2) Competence area documentation (25% of the grade): Poster presentation (elaboration of the theoretical background, presentation of the results, lecture and discussion); Duration: 30 minutes

Requirements for award of credit points
(1) Passing the module exam
(2) Regular and active participation in lectures and practical courses
(3) Participation in the discussion rounds
(4) Presentation of a poster

Assignment to specialisation field
A) Cell & organ biology

Module applicability in other study courses
None

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German and English

Further information
The module is assigned centrally. Attendance at the preliminary meeting is mandatory.

M2520 Molecular virology and structural biology

Molecular virology and structural biology

Module convenor
N.N.

Lecturers
Dr. Lisa Müller, PD Dr Albert Zimmermann, Prof Dr Ingo Drexler, PD Dr Bernd König, Dr Philipp Neudecker, further lecturers and staff members

Module organisation
Dr. Lisa Müller (lisa.mueller@uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Summer and winter term	2 Students

Learning outcomes/competences
The students should master the principles of retroviral gene transfer, be able to explain the structure of a lentiviral vector, be able to name its essential sequence prerequisites and be able to design a vector for gene transfer themselves and translate it into a practical guide for its realisation.
They know the molecular principles of antiviral immune responses and viral immune evasion versus these responses. You will be able to experimentally detect antiviral immune responses and viral immune evasion.
They are familiar with the basics of the adaptive immune system to fight viral infections and can name examples of viral evasion mechanisms.
They should be able to reproduce texts with virological content, such as a newspaper article about a vaccination recommendation or a report on the manifold possibilities of a virus to escape an immune response of the cell, in their own words, explain and assess the technical facts and be able to derive implications.
Students can explain the basic concepts of solution NMR spectroscopy, the basic structure of a high-field NMR spectrometer and the possible applications of NMR in biology. They can independently record, process and analyze NMR spectra. The students are able to calculate protein structures from experimental data and graphically represent them on the computer. Students are enabled to plan, perform and evaluate NMR titration to study the binding of a ligand to a protein.
On the basis of the acquired knowledge, students can independently document, evaluate and discuss all experiments carried out.

Forms of teaching
Lecture, Practical course

Contents
Lecture:
(1) Classification of viruses
(2) Virus entry into the cell
(3) Replication of positive and negative-stranded RNA viruses; Replication cycle of retroviruses
(4) Retroviral vectors for introducing foreign genes into eukaryotic cells; Pseudotyping
(5) Processing of viral pre-mRNA; Translational control of viral gene expression
(6) Host restrictions
(7) Innate immunity and immune evasion; Interferon-dependent signal transduction processes
(8) Adaptive immunity and viral immune evasion I; Antibody-mediated B cell immunity; Antibody-mediated cytolysis (ADCC)
(9) Adaptive immunity and viral immune evasion II; MHC-I and II-mediated antigen presentation and T cell immunity
(10) Epidemiology and control of viral diseases

(11) Non-retroviral viruses as gene ferries for clinical use (immunotherapy)
(12) Virus evolution
(13) General basics of NMR spectroscopy: FT-NMR, one- and multidimensional NMR, experimentally determined parameters (chemical shift, scalar coupling, dipolar coupling, nuclear Overhauser effect - NOE), high-field NMR spectrometer
(14) NMR on biomacromolecules: isotope labeling and recombinant production, accessible information (spatial structure, dynamics, interactions).
(15) Strategies for data evaluation: resonance mapping, determination of geometric parameters, molecular dynamic structural calculus
(16) Analysis of protein-ligand interactions by NMR
(17) Biological background: Interaction of HIV-1 Nef with SH3 domains

Practical course:
(1) Cell culture of eukaryotic cells, transfection, transduction
(2) Harvesting virus supernatants, infection
(3) Titer determination, fixing and staining cells
(4) Cloning of lentiviral vectors
(5) Detection of interferon-dependent signal transduction and viral immune evasion: Reporter gene assay, Western blot
(6) Proof of interferon effect: Virus titer determination by plaque test and final dilution
(7) Modulation of NK cell responses by viruses
(8) Acquisition and analysis of NMR spectra (software *nmrPipe*)
(9) Resonance mapping using 2D and 3D NMR spectra (*CARA*)
(10) NMR-based titrations of the 15N-Hck-SH3 with the ligands Nef-peptide and Nef-core
(11) Creating and evaluating binding isotherms (*qtiplot*)
(12) Calculation of SH3 structure from NMR data using molecular dynamics (*CYANYA)*
(13) Visualize the SH3 structure and map the peptide binding sites

Prerequisites
Formal: Admission to master's programme
Content: Knowledge of cell culture desired; Interest in structural biology and computational data analysis

Type of examination
(1) Knowledge competence area (70% of the grade): Oral examination on the contents of the lecture and the practical course; Duration: 30 minutes
(2) Competence area documentation (30% of the grade): Protocol (presentation of the basics, description of the work steps, documentation and discussion of the results); Length of the protocol: Approx. 45 pages

Prerequisites for the award of credit points
(1) Passing the competence area knowledge
(2) Regular and active participation in the Practical course
(3) Protocol that meets the requirements for scientific documentation

Assignment to specialisation field
B) Immunology, infectiology, inflammation & stem cell biology

Module applicability in other study courses
Master Biology

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German and English

Further information
A place in the module is allocated centrally. The structural biology section takes place at Forschungszentrum Jülich (there is a shuttle bus between HHU Düsseldorf and FZ Jülich).

M2530 Molecular medical immunology

Molekulare Medizinische Immunologie

Module convenor
Prof Dr M. Uhrberg (markus.uhrberg@med.uni-duesseldorf.de)

Lecturers
Prof Dr Markus Uhrberg, PD Dr Rüdiger Sorg, Dr Jürgen Enczmann, Dr Thorsten Trapp, Dr Hans-Ingo Trompeter, Dr Simeon Santourlidis, Prof Dr Gesine Kögler, Dr Sandra Weinhold, Dr Angeliki Datsi, further lecturers and staff members

Module organisation
Prof Dr M. Uhrberg (markus.uhrberg@med.uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Summer term	8 Students

Learning outcomes/competences
Immunological barriers, natural immunity, initiation and effector phase of an immune response, immune memory, mechanisms of gene regulation by miRNAs, transcription factors, and epigenetics as well as signal transduction pathways of the different immune cell types can be explained and the components involved can be named. The basic immunological mechanisms can be transferred to concrete and clinically relevant examples. Basic techniques (i.e. isolation of lymphocytes from peripheral blood) can be performed independently. The principles of various advanced immunological techniques (i.e. HLA and KIR typing, flow cytometry) can be explained and applied. The test results can be analyzed, graphically evaluated and formulated in writing.

Contents
Lecture:
Non-adaptive and adaptive immunity, inflammatory process, T cell and B cell diversity, T and B cell response, tumour immunology, natural killer cells, dendritic cells, KIR receptors, immune receptor signal transduction, transplantation immunology, MHC class I and II, immunological methods. Fundamentals of epigenetics, its significance for immunology. Fundamentals of the biology of microRNAs, importance of microRNAs in immunology. Pathophysiology of autoimmune diseases. Immunopharmacology.

Practical course:
- Immunogenetic determinations and functional analyses of human cell lines, primary lymphocytes (T, B and NK cells) and dendritic cells (PCR, RT-PCR, HLA class I and II typing, KIR typing, processing of blood samples, proliferation assays, mixed lymphocyte cultures (MLC), cytotoxicity assay, transfection of primary lymphocytes, flow cytometry).
- in vitro differentiation of haematopoietic stem cells into NK cells,
- Migration behaviour of monocytes and dendritic cells (migration tests, microscopy), regulation of the production of indolamine-2,3-dioxigenase by dendritic cells (stimulation of dendritic cells, detection of IDO enzyme activity), induction of epithelial-mesenchymal transition of tumour cells (cell culture of human tumour cells, stimulation and stromal coculture of tumour cells, immunohistochemistry, RT-PCR).
- Experimental detection of microRNA target proteins, overexpression of microRNAs , influence of microRNAs on the expression of a target protein
- Decoding DNA methylation: a) genomic sequencing after bisulfite treatment, b) introduction to NimbleGen array analysis
- Studies on the molecular pharmacology of glucocorticoids by reporter assay

Forms of teaching
Lecture and practical course, seminar

Prerequisites
Formal: Admission to Master´s programme Molecular Biomedicine
Content: Basic knowledge of genetics and cell biology is required.

Type of examination (1) Competence area knowledge (70% of the grade): Written examination on the contents of the lecture and the practical course; Duration: 120 minutes (2) Competence area scientific presentation (30% of the grade): Seminar lecture (development of the material, graphic representation of the contents, lecture, discussion); Duration: 20 minutes
Requirements for award of credit points (1) Regular participation in the practical exercises (2) Passed final module examination (3) Seminar lecure
Assignment to specialisation field B) Immunology, infectiology, inflammation & stem cell biology
Module applicability in other study courses None
Assessment The grade is weighted according to the credit points (CP) in the overall grade: MSc Molecular Biomedicine 14/72 CP.
Language of instruction German and English
Further information The module is assigned centrally. Presence at the preliminary meeting is mandatory. Attention: 4 to 5 days are identical with Master-Modul M2570 Stemcell Biology & Tissue Regeneration

M2540 Immunology & Host-pathogen interaction

Immunologie & Wirt-Pathogen Interaktion

Module convenor
Prof Dr Charlotte Esser (chesser@uni-duesseldorf.de)

Lecturers
Prof Dr Charlotte Esser, Prof Dr Stefanie Scheu, Prof Dr Marc Jacobsen, Dr Daniel Degrandi, Dr Ursula Sorg, Prof Dr Alexander Dilthey, further lecturers and staff members

Module organisation
Prof Dr Charlotte Esser (chesser@uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Summer term	4 Students

Learning outcomes/competences
Students can specify the basic concepts as well as involved organs, cells and molecules of the immune system. They can also name basic and typical methods for studying the immune system.
They are able to explain immunological phenomena and interpret experimental data. They can explain the most important physiological functions and malfunctions of the immune system and understand the experimental basis on which immunological findings were obtained. Students will be able to distinguish unique characteristics of the immune system from those of other organ systems and systematize common fundamental biological processes.
They proceed experimentally methodically and are able to evaluate and interpret data. They can develop a relevant experimental procedure for a given question and systematically document their experiments. You can display and use various graphical evaluations.
You can solve tasks from this area independently and adapt test conditions. They know the basic legal framework of laboratory work, especially in the field of animal welfare and chemical safety.
Students can handle the flow cytometer and gain practical experience working at the sterile workbench. Basic molecular and cell biological as well as typical immunological methods, such as Western blotting, quantitative PCR, ELISA or immunohistology, are understood, applied and used correctly according to their theoretical background.

Contents
Basic theoretical knowledge of immunology; immunotoxicology, immunopathology; practical: mouse anatomy, immunohistology, introduction to cell culture; in vitro differentiation of immune cells, blood count differentiation, flow cytometry, cell sorting with MACS, toxoplasma infections, humoral immune response, cytokine measurements, immunisation, Western blotting, ELISA, proliferation assays, etc. (subject to change)

Forms of teaching
Lecture and practical course, group work, minute keeping, literature seminar.

Prerequisites
Formal: Admission to master's programme
Content: The following basics should be known: genetics and molecular biology, basic knowledge of chemistry/biochemistry are required.

Type of examination
(1) Competence area knowledge (70% of the grade): Oral examination on the contents of the lecture and the practical course; Duration: 60 minutes
(2) Documentation competence area (20% of grade): Protocol (topic, implementation, evaluation and discussion of scientific experiments); Length of the protocol: Approx. 40 pages
(3) Competence area scientific presentation (10% of the grade): Seminar lecture in English (elaboration of the content, visual presentation of the content, lecture, discussion); Duration: 30 minutes

Prerequisites for the award of credit points
(1) Passing the competence areas knowledge, documentation, scientific presentation

(2) Regular and active participation in the practical course (3) Submission of a protocol that meets the requirements of scientific documentation
Assignment to specialisation field B) Immunology, infectiology, inflammation & stem cell biology
Module applicability in other study courses Master Biology
Assessment The grade is weighted according to the credit points (CP) in the overall grade: MSc Molecular Biomedicine 14/72 CP.
Language of instruction German and English
Further information The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M2570 Stem cell biology and tissue regeneration

Stammzellbiologie und Geweberegeneration

Module convenor
Prof James A. Adjaye (James.Adjaye@med.uni-duesseldorf.de)

Lecturers
Prof Dr James A. Adjaye, Prof Dr Gesine Kögler, PD Dr Thorsten Trapp, PD Dr Simon Santourlidis, Dr Stefanie Liedtke, Dr Claus Kordes, Dr Boris Görg, Dr Ingo Trompeter, Dr Johannes Fischer, Dr Nina Graffmann, further lecturers and staff members

Module organisation
ISRM: Dr Nina Graffmann (nina.graffmann@med.uni-duesseldorf.de); ITZ: Prof Dr Gesine Kögler (Gesine.Koegler@med.uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	SS & WS	8 Students

Learning outcomes/competences
Students can explain the basic characteristics of stem cells, their origin and their role in tissue regeneration and tumourigenesis. In the practical course, biochemical, cell biological, immunocytochemical and molecular biology experiments are carried out independently under supervision. The students can explain the theories underlying the experiments and are able to handle the required equipment properly. The students document the experiments in rule-compliant protocols, evaluate them and discuss them critically. They are able to present their own results and specialist literature in a lecture. The basics of bioethical reasoning are mastered and applied to aspects of stem cell medicine.

Forms of teaching
- Lecture
- Practical course
- Self study with e-learning materials and specialist literature
- Small group lessons with presentation of practical course results and current specialist literature as well as ethical case seminar

Contents

Lecture:
- Fundamentals of stem cell biology
- Classification, origin and characteristics of stem cells (embryonic SZ, IPSC, adult SC, neonatal SZ, mesenchymal SZ, hematopoietic SZ, tissue SC)
- Stem cell niches
- Basics of tissue regeneration
- Animal models for the investigation of regenerative processes
- Mechanobiology
- Introduction to modern techniques of light microscopy
- Role of stem cells in tumour biology
- Disease modelling
- Basics of flow cytometry and cell sorting
- Molecular mechanisms of cell migration
- Regenerative Pharmacology
- Epigenetics of stem cells
- Transcriptional and post-transcriptional regulation of stem cells / Fundamentals of microRNA biology
- Clinical aspects of stem cell transplantation
- Legal aspects of stem cell medicine
- Bioethics

Practical course:
- Isolation of stem cells from the blood
- Cultivation of cells
- Characterisation of stem cell migration by agarose invasion and scratch assay
- Wound healing assay
- Characterisation of stem cell markers by flow cytometry
- Cell sorting by FACS, positive and negative selection of cells
- Stem cells as the basis for disease models
- Modulation of apoptotic signal transduction by stem cells
- Expression analysis of stem cell-relevant proteins by Western blot and immunocytochemistry (fluorescence microscopy)
- Expression analysis of stem cell-relevant genes by PCR
- Multipotent differentiation of adult and neonatal stem cells under different oxygen conditions
- Characterisation of epigenetic changes in stem cells / analysis of DNA methylation
- Analysis of micro-RNA expression and its effect in post-transcriptional regulation in stem cells
- Bioinformatic analysis
- Fluorescence in situ hybridisation for the detection of chromosomes
- Histological staining techniques on regenerating tissue
- Mechanical stimulation of cells for the analysis of released messenger substances
- Modern,light microscopy (*Core Facility Advanced Light Microscopy*)

Prerequisites
Formal: Admission to Master´s programme Molecular Biomedicine
Content: None

Type of examination
1. Competence area knowledge (50% of the grade): Written examination on the contents of the lecture and the practical course; Duration: 120 minutes
2. Competence area documentation (30% of the grade): protocols (topic, implementation, evaluation and discussion of scientific experiments); Length of the protocol: Approx. 60 pages
3. Competence area scientific presentation (20% of the grade): Seminar lecture (development of the material, presentation of the contents, lecture, discussion); Duration: 20 minutes

Prerequisites for the award of credit points
1. Passing the competence area knowledge
2. Regular and active participation in the practical course
3. Submission of compliant protocols
4. Presentation of a seminar lecture

Assignment to specialisation field
B) Immunology, infectiology, inflammation & stem cell biology

Module applicability in other study courses
None

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German and English

Further information
The module is assigned centrally. Presence at the preliminary meeting is mandatory. Attention: 4 to 5 days are identical with Master-Modul M2530 Molecular medical immunology

M2580 Immunological principals of viral infection

Immunologische Prinzipien der Virusinfektion

Module convenor
Prof Philipp Lang (philipp.lang@med.uni-duesseldorf.de)

Lecturers
Prof Philipp Lang, Prof Jörg Timm, Prof Ingo Drexler, Dr Andreas Walker, Dr Haifeng Xu, Dr Michal Gorzkiewicz, further lecturers and staff members

Module organisation
Institute of Molecular Medicine II (Admin_Lang@uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Summer term	8 Students

Learning outcomes/competences
This course will cover the topic of immunology in viral infections. Viral infectious diseases – including hepatitis viruses – are a global health problem with millions of patients worldwide. The body's own immune defense manages to protect the organism from viral invaders day after day. In this course, different mechanisms of the anti-viral immune response are taught. These include the activation of the innate immune system as well as the activation of the acquired cellular and humoral immune response against viruses. Current examination techniques of immunology and virology are taught in experimental and clinical situations. In addition, the data collected in the practical course will be presented.

Forms of teaching
Lecture, practical courses, seminars, presentations

Contents

Lecture:
- Fundamentals of laboratory safety
- Fundamentals of Immunology
- Activation of the innate immune system by viruses
- Function of anti-viral cytokines
- Function of B cells and antibody production
- Development and activation of T cells
- Effector mechanisms of anti-viral T cells
- Activation and function of NK cells
- Basics of virology
- Immune evasion mechanisms of viruses

Practical course:
- Cell culture, laboratory basics
- Tissue section microscopy of lymphoid organs
- Activation of cells of the innate immune system (i.e. dendritic cells)
- Activation of T cells and cytokine production
- Cytokine determination, flow cytometry

- Activation of NK cells
- Biomedical research methods in the study of viral infections
- Methods for the direct and indirect detection of virus-specific T cells
- Molecular detection and sequencing of viruses
- Determination of antibody titer and neutralisation assays

Seminar:
- Summary and evaluation of results
- Presentation of the data collected in the practical course

Prerequisites
Formal: Admission to Master´s programme Molecular Biomedicine
Content: Basic knowledge of cell biology, biochemistry and immunology

Type of examination
(1) Competence area knowledge (70% of the grade): Oral examination on the contents of the course; Duration: 15 minutes
(2) Competence area documentation (15% of the grade): Presentation of the analyses through photos and notes, execution of the experiments and their analyses; Length of the protocol: Approx. 60 pages
(3) Competence area scientific presentation (15% of the grade): Lecture (elaboration of the content, visual presentation of the content, lecture, discussion); Duration: 15 - 20 minutes

Prerequisites for the award of credit points
(1) Regular and active participation in the practical course and submission of a protocol
(2) Presentation of a seminar lecture
(3) Passing the oral exam on the contents of the module

Assignment to specialisation field
B) Immunology, infectiology, inflammation & stem cell biology

Module applicability in other study courses
None

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German and English (Presentation of the students and individual practical course parts in English)

Further information
The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M3510 Molecular biomedicine of inner organs

Molekulare Biomedizin der inneren Organe

Module convenor
Prof Dr Eckhard Lammert (lammert@uni-duesseldorf.de)

Lecturers
Prof Dr Eckhard Lammert, Dr Daniel Eberhard, further lecturers and staff members

Module organisation
Dr Daniel Eberhard (daniel.eberhard@uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Winter term	20 Students

Learning outcomes/competences
Students are able to describe, apply and analyze the basic concepts of organ development, physiology, cell biology and biomedicine of selected organs (such as pancreas and blood vessels) as well as organ diseases (such as diabetes mellitus and heart attack). Students are able to independently carry out and plan tissue biology and cell biological techniques and experiments on biomedically relevant organs (such as .dem cardiovascular system). The students can independently and precisely handle light microscopes, fine tools, ELISA, real-time PCR, gel documentation system and other modern equipment and instruments from the laboratory.

Forms of teaching
Lecture, practical course

Contents
Lecture:
General basics of biomedicine, the development, function and disease of internal organs and tissues, the disease models of some human diseases as well as techniques of tissue and cell cultures are taught.
Practical course:
General methodology for cell biology, developmental biology and biomedicine of internal organs, application of cell biological, physiological and biomedical research methods for the analysis of selected embryonic and adult organs, such as isolation of embryos and islets of Langerhans under the stereomicroscope, preparation of frozen sections, immunohistochemistry, laser scanning microscopy (LSM), time lapse video microscopy, insulin secretion ELISA, angiogenesis assay, Western blots, tissue and cell culture and image analysis, are taught.

Prerequisites
Formal: Admission to master's programme
Content: Reading the script

Type of examination
(1) Competence area knowledge (70% of the grade): Written examination (as a rule) on the contents of the lecture and the practical course; Duration: 90 minutes
(2) Competence area documentation (30% of the grade): Preparation of a protocol (topic, implementation, evaluation and discussion); Volume: approx. 40 pages

Prerequisites for the award of credit points
(1) Passing the competence area knowledge
(2) Regular and active participation in the practical course
(3) Submission of a protocol that meets the requirements of scientific documentation
(4) Seminar lecture on in-depth topics of the module

Assignment to specialisation field
C) Metabolism, metabolic and cardiovascular diseases

Module applicability in other study courses
Master Biology, Master Biochemistry

Assessment

The grade is weighted according to the credit points (CP) in the overall grade: MSc Molecular Biomedicine 14/72 CP.
Language of instruction English
Further information The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M3520 Cardiovascular biology

Kardiovaskuläre Biologie

Module convenor
Elvers (margitta.elvers@uni-duesseldorf.de)

Lecturers
Prof Margitta Elvers, Dr Lili Donner, Prof Norbert Gerdes, Dr Wiebke Ibing, PD Dr Wagenhäuser, Prof Maria Grandoch, Prof Ulrich Flögel, Dr Sebastian Temme

Module organisation
Dr Kim Krott und Lili Donner (kim-juergen.krott@med.uni-duesseldorf.de; lili.donner@med.uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 h	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Summer term	8 Students

Learning outcomes/competences
Students are able to describe and analyze the basic concepts of cardiovascular biology, physiology and pathophysiology. These include, in particular, the differences in the structure, function and regulation of the arterial and venous vessel sections as well as the distinction between the high and low pressure system. They know essential mechanisms for the regulation of cardiac function (inotropy, lusitropy, chronotropy). They know basic methods for measuring cardiac function and blood pressure and are familiar with experimental approaches for measuring function on isolated organs (Langendorf preparation, isol. Aortic rings). They know the function and structure of the essential cell types of the cardiovascular system (cardiomyocytes, endothelium, gl. Muscle cells, fibroblasts, pericytes) including circulating cells (monocytes, granulocytes, lymphocytes, platelets) as well as the basics of cell-cell communication. Furthermore, the students should know essential pathomechanisms that lead to cardiovascular dysfunction (atherosclerosis, coagulation disorders, cardiac hypertrophy, heart failure, heart attack, hypertension). In particular, they are familiarized with imaging techniques for measuring heart and vascular function (echocardiography, MRI, intravital microscopy).
Students are able to independently carry out and plan basic molecular biological, immunohistological and physiological techniques/experiments for the analysis of the cardiovascular system. The students can display results in illustrations according to scientific standards and use the necessary computer programs (Excel, Photoshop, Illustrator). Students are able to evaluate data quantitatively using the necessary statistical methods. Students can independently handle measuring instruments and other instruments from the laboratory.

Forms of teaching
Lecture, practical course, seminar

Contents:
The focus of the module is the practical training of students in small groups in the areas mentioned. The theoretical basics will be taught in a lecture. On the basis of further literature, students prepare their results (value tables, charts, statistical analysis) and present their data in connection with the selected literature. The results, including error discussion, are done in the group.

Cardiac functional analysis: Fundamentals of cardiac physiology including regulatory mechanisms in *vitro* and *in vivo*: isolated perfused mouse Langendorff heart (constant pressure and volume perfusion, coronary blood flow, Frank-Starling mechanism, β-adrenergic stimulation), mouse echocardiography (basal function, cardiac hypertrophy), measurement of wall thicknesses, systolic and diastolic ventricular volumes, stroke volume, ejection fraction)

Vascular functional analysis: investigations on isolated aortic rings, influence of vasoconstrictors (angiotensin II, endothelin) and vasodilators (NO; Adenosine; Prostacyclin) on vascular tone, NO

analysis (DAF-DA, chemiluminescence, semolina reaction). Creation of concentration-effect curves, curve analysis

Cardiovascular imaging: Cardiovascular imaging (MRI, echo, CT); Contrast medium; targeting, coupling reactions, antibodies and their derivatives; Understanding inflammatory mechanisms. Practical part: production of "targeted" contrast agents PFCs; imaging of thrombi; uptake of contrast agents by cells by MRI, FACS; Immunofluorescence; IVIS; Bioluminescence; Echo; Biotinylation; SDS-PAGE of antibodies, nanobodies, Fab fragments, etc.; Coupling and purification of antibodies

Pathophysiology of atherosclerosis: Anatomy of the cardiovascular system in a mouse model with subsequent analyses for the quantitative and qualitative assessment of atherosclerosis. The individual steps include (I) learning the mouse anatomy with dissection of the heart, aorta and *brachiocephalic artery* as important anatomical target structures for the in-depth analysis of atherosclerosis, (II) the independent preparation of the aorta for the subsequent implementation of the oil-red-O staining for the quantitative analysis of lipid deposits in *en face* preparations as well as (III) the analysis of atherosclerotic lesions of the aortic origin with regard to immune cell accumulation (Mac2 staining) or plaque composition (collagen staining) using the analysis software Image J as well as subsequent presentation in image form and statistical evaluation (GraphPad Prism Software).

Platelets/coagulation: activation of platelets (collagen, ADP), detection of thrombocytic proteins by SDS PAGE and Western blot, importance of individual receptors on the platelet surface (FACS analysis), platelet aggregation, platelet adhesion and thrombus formation, static and under flow conditions (using different shear rates).

Prerequisites
Formal: Admission to Master's programme Molecular Biomedicine
Content: Basic knowledge of molecular and cell biology and organ physiology

Type of examination
1. Competence area knowledge (50% of the grade): Written examination of the contents of the lecture and the practical course; Duration: 60 minutes
2. Competence area documentation (35% of the grade): Protocol (topic, implementation, evaluation and discussion of scientific experiments); Length of the protocol: approx. 50 - 80 pages
3. Area of competence scientific presentation (15% of the grade): Presentation (development of the material, graphic representation of the contents, lecture, discussion); Duration: 20 - 25 minutes

Prerequisites for the award of credit points
(1) Regular participation in the practical course and presentation of experiments and analyses
(2) Presentation of a lecture in the seminar
(3) Passing the competence area knowledge

Assignment to specialization field
C) Metabolism, metabolic and cardiovascular diseases

Module applicability in other study courses
None

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/ 72 CP.

Language of instruction
German and English

Further information
The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M3530 Insulin resistance and diabetes mellitus

Insulinresistenz und Diabetes mellitus

Module convenor
Prof Dr Hadi Al-Hasani (hadi.al-hasani@ddz.de)

Lecturers
Prof Dr Hadi Al-Hasani, Dr Alexandra Chadt, Dr Stefan Lehr, further lecturers and staff members

Module organisation
Prof Dr Hadi Al-Hasani (hadi.al-hasani@ddz.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Winter term	6 Students

Learning outcomes/competences
The course provides comprehensive knowledge about the basics of insulin action and pathomechanisms in the development of diabetes mellitus, especially type 2. Concepts of disease development are developed and important cell and animal models of current diabetes research are presented comparatively. Current experimental techniques and evaluation methods for the investigation of glucose and fat metabolism are learned in the Practical course. Basics of transcriptome and pathway analysis are taught. Molecular basis of early detection (i.e. biomarkers) and therapy of the disease (i.e. pharmacological intervention, activity and duration training) as well as gene/lifestyle interactions and the investigation of complex protein signatures using mass spectrometric techniques are important components of the event. The module is aimed at interested parties who would like to work successfully in experimental diabetes research (academic research institutes/industry).

Forms of teaching
Lecture, practical course, presentations

Contents
Lecture:
Basics of energy and substrate metabolism; Insulin-dependent signalling pathways; structure, function and regulation of glucose and fatty acid transporters; Rab-GTPases and the regulation of protein trafficking; disorders in insulin action and molecular pathophysiology of type 2 diabetes; physiology of adipose tissue, fat deposits, *browning* and thermogenesis; Muscle physiology and molecular adaptation to activity and training. intraorgan crosstalk in metabolic regulation (adipokines, myokines); *In vitro* and *in vivo* models of type 2 diabetes; Complex genetics of diabetes in mice and humans; Positional cloning of diabetes genes; gene/environment interaction; Omics and systems biology approaches with a focus on the analysis of highly complex data sets (protein mass spectrometry); Molecular basis of new therapeutic approaches for diabetes.

Practical course:
1. Cultivation, differentiation and characterisation of 3T3-L1 adipocytes and C2C12 myotubes
2. Molecular characterisation of glucose, lipid and energy metabolism
3. *In vitro* muscle contraction and cellular adaptation
4. Biochemical analysis of signalling pathways in experimental insulin resistance
5. Genotyping by KASP (*Competitive allele specific PCR*) for further application in coupling analyses for T2D-associated quantitative traits.
6. Basics of transcriptome analysis and use of biomedical databases and analysis tools
7. Sample preparation and mass spectrometric analysis to investigate global protein phosphorylation

Techniken:

1. Cell culture techniques, cell differentiation
2. Biochemical analysis of metabolites, fluorimetric/colorimetric assays
3. Quantitative protein determination, SDS-PAGE, Western blot, quantitative real-time PCR
4. Cell transfection, siRNA knockdown and plasmid overexpression
5. Electrical stimulation/contraction of muscle cells *in vitro*
6. Measurement of cellular energy metabolism using Seahorse technology
7. KASP genotyping
8. Coupling analysis with R-Studio software
9. Signalling path and network analysis of the transcriptome using ConsensusPathDB (CPDB) and Ingenuity Pathway Analysis (IPA)
10. Use of biomedical databases and analysis tools, "data mining" (BioMart, NCBI, Ensembl)
11. Protein mass spectrometry (phosphoproteomics)
12. Data analysis of highly complex data sets (network analyses)

Prerequisites

Formal: Admission to Master´s programme Molecular Biomedicine

Content: Basic knowledge of physiology, biochemistry and genetics

Type of examination

(1) Competence area knowledge (50% of the grade): Written examination of the contents of the lecture and the practical course; Duration: 90 minutes
(2) Competence area documentation (30% of the grade): Protocol (topic, implementation, evaluation and discussion of scientific experiments); Length of the protocol: approx. 30 pages
(3) Competence area scientific presentation (20% of the grade): Seminar lecture (development of the material, graphic representation of the contents, lecture, discussion); Duration: 20 minutes

Requirements for awarding credit points

1) Regular and active participation in the practical course
2) Presentation of a seminar lecture
3) Passing the final exam consisting of the contents of the lecture and the practical course
4) Keeping a lab notebook

Assignment to specialisation field

C) Metabolism, metabolic and cardiovascular diseases

Module applicability in other study courses

None

Assessment

The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction

German and English

Further information

The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M3540 Evolution and biochemistry of organelles

Evolution und Biochemie der Organellen

Module convenor
Prof Dr William Martin (w.martin@hhu.de)

Lecturers
Prof Dr William Martin, Dr Verena Zimorski

Module organisation
Dr Verena Zimorski (zimorski@hhu.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Winter term	2 Students

Learning outcomes/competences
The students are able to describe the biochemical compartmentalization of eukaryotic cells in cytosol and organelles – in particular the different forms of mitochondria – and to represent, interpret, compare and analyze the biochemical diversity of these organelles in the different groups of eukaryotes. They can describe and comment on the endosymbiotic origin of organelles and cell compartmentalization from the perspective of early cell evolution. Students are able to independently plan, apply, implement and critically interpret biochemical and molecular biological working methods. They can independently plan, perform and critically comment on basic methods of cell disruption, centrifugation techniques, sample preparation and performance of 2D electrophoresis techniques, cloning techniques and heterologous and homologous expression of eukaryotic proteins in prokaryotic and eukaryotic systems.

Forms of teaching
Lecture with practical exercises in the laboratory.

Contents
Compartmentalization of eukaryotic cells. Endosymbiotic origin of organelles. Diversity of mitochondria and chloroplasts. Application of protein biochemical research methods. Application of basic molecular biological techniques. Heterologous and homologous expression of proteins in pro- and eukaryotes. For further information, please consult the following Web address: https://www.molevol.hhu.de/m3540

Prerequisites
Formal: Admission to master's programme
Content: None

Type of examination
(1) Competence area knowledge (50% of the grade): Written examination on the contents of the lecture and the practical course; Duration: 90 minutes
(2) Competence area documentation (50% of the grade): Protocol (written evaluation and discussion of scientific results); Length of the protocol: Approx. 40 pages

Prerequisites for the award of credit points
1. Regular and active participation in the module
2. Passing the competence area knowledge
3. Submission of a protocol that meets the requirements of scientific documentation

Assignment to specialisation field
C) Metabolism, metabolic and cardiovascular diseases

Module applicability in other study courses
Master Biology

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German

Further information
The module is assigned centrally. Attendance at the preliminary meeting is mandatory.

M3560 Molecular pharmacology and biotechnology

Molekulare Pharmakologie und Biotechnologie

Module convenor
Prof Miriam M. Cortese-Krott (miriam.cortese@HHU.de)

Lecturers
Prof Dr Miriam Cortese-Krott, Prof Ulrich Flögel, Prof Dr Maria Grandoch, PD Dr Tanya Suvorava, Prof Bodo Levkau, PD Dr Csaba Mahotka, Prof Joachim Schmitt, further lecturers and staff members

Module organisation
Prof Miriam M. Cortese-Krott (miriam.cortese@HHU.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Winter term	6 Students

Learning objectives/competences
Students are able to describe and analyze the fundamental concepts of molecular pharmacology and biotechnology. These include, in particular, fundamentals of molecular pharmacology such as the definition and function of molecular targets (receptors, ion channels, enzymes, transcription factors). They know the definition of biologics (such as antibodies and vaccines) and their application. Further basics are structure, function and regulation of signaling cascades, relevant for the regulation of cell physiology (excitation, contraction, relaxation) and its pharmacological modulation as well as basics of absorption, distribution and excretion of pharmaceuticals and biologics. They know the basic principles of clinical trials. They know the effects of vasoactive substances, nitric oxide *signalling*, anti-inflammatory drugs, anesthetics (and their use in the laboratory), and RNA vaccines. In the laboratory, they will be familiarized with analytical methods for the determination of nitric oxide metabolites, metabolomics (amino acids and fats), enzymatic analysis, cell culture, microscopy and imaging techniques for the measurement of cardiac and vascular function (echocardiography and MRI) and its pharmacological modulation. Students are able to independently carry out and plan basic techniques/experiments. Students can create illustrations from measurement results according to scientific standards and present them. The students can evaluate data quantitatively and apply the necessary statistical methods as well as independently handle measuring instruments and other instruments from the laboratory.

Forms of teaching
Lecture, practical course, seminar

Contents
The focus of the module is the practical training of students in small groups in the areas mentioned. The theoretical basics will be taught in a lecture. On the basis of further literature, students prepare their results (value tables, charts, statistical analysis) and present their data in connection with the selected literature. The results, including their error discussion, are discussed in the group.

Nitric oxide and vascular functional analysis (Cortese-Krott): Effect of nitric oxide in cardiovascular system, vasodilators (NO; Adenosine; Prostacyclin) on vascular tone, NO analysis (DAF-DA, chemiluminescence, semolina reaction). Creation of concentration-effect curves, curve analysis. Presentation of the results in image form and statistical evaluation (GraphPad Prism Software).

Cardiovascular imaging and simulation of cardiac function (Flögel*):* Fundamentals of cardiac physiology including regulatory mechanisms in *vitro* and *in vivo*. Cardiovascular imaging (MRI, echo, CT); Contrast medium; targeting, coupling reactions, antibodies and their derivatives; Understanding inflammatory mechanisms. Practical part: production of "targeted" contrast agents PFCs; imaging of thrombi; uptake of contrast agents by cells by MRI, FACS; Immunofluorescence; IVIS; Bioluminescence; Echo; Biotinylation; SDS-PAGE of antibodies, nanobodies, Fab fragments, etc.;

Coupling and purification of antibodies. Presentation of the results in image form and statistical evaluation (GraphPad Prism Software).

Insulin signalling cascade and diabetes (Grandoch): Introduction to the topic and practical work. The individual steps include (1) in vitro cell culture (i.e. SMCs) with agonists/antagonists of various pathways (including AngII) as well as Western blots or functional analyses such as migration, proliferation. In vitro cell culture of preadipocytes and differentiation by insulin cocktail, Oil Red O staining, mRNA expression of differentiation markers. In vivo GTT's analysis of the insulin pathway. Presentation of the results in image form and statistical evaluation (GraphPad Prism Software).

Pharmacology of sphingolipid metabolism (Levkau): The molecular basis of clinically relevant diseases of sphingolipid metabolism is investigated experimentally in various organ systems and cell types using various methods (cell culture, organ preparation, flowcytometry, gene expression analyses (real time PCR), mass spectrometry. The focus is on the bioactive sphingolipid sphingosine-1-phosphate (S1P) and its regulation by pharmacological intervention. This makes it possible to develop therapeutic concepts for various metabolic diseases. Presentation of the results in image form and statistical evaluation (GraphPad Prism Software).

Cardiomyocyte isolation and Ca^{++} signalling (Schmitt): Basics of adrenergic signalling, excitation-contraction-coding in cardiomyocytes, isolation and cultivation of cardiomyocytes and their beta-adrenergic stimulation followed by Western blots of PKA targets; Stimulation Receptor-specific or conc.-dependent to establish dose-response relationships. Functional read-outs are analyzed (i.e. contractile cycles of cardiomyocytes or heart tissue +/- isoprotrenol). Presentation of the results in image form and statistical evaluation (GraphPad Prism Software).

Prerequisites
Formal: Admission to Master´s programme Molecular Biomedicine
Content: Basic knowledge of molecular and cell biology and organ physiology

Type of examination
1. Competence area knowledge (70% of the grade): Written examination of the contents of the lecture and the practical course; Duration: 60 minutes
2. Competence area documentation (15% of the grade): Protocol (topic, implementation, evaluation and discussion of scientific experiments); Length of the protocol: approx. 40 pages
3. Area of competence scientific presentation (15% of grade): seminar lecture (development of the material, graphic representation of the contents, lecture, discussion); Duration: 10 minutes

Prerequisites for the award of credit points
(1) Regular participation in the practical course
(2) Presentation of a lecture in the seminar
(3) Passing the competence area knowledge, documentation, scientific presentation

Assignment to specialisation field
C) Metabolism, metabolic and cardiovascular diseases

Module applicability in other study courses
None

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German and English

Further information
The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M4520 Conformation, misfolding and aggregation of biological macromolecules: From Alzheimer's to Parkinson's disease

Konformation, Fehlfaltung und Aggregation von biologischen Makromolekülen: Von Alzheimer bis Parkinson

Module convenor
Willbold (willbold@uni-duesseldorf.de)

Lecturers
Prof Dr Dieter Willbold, Dr Luitgard Nagel-Steger, further lecturers and staff members

Module organisation
Dr Luitgard Nagel-Steger (luitgard.nagel-steger@HHU.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Winter term	8 Students

Learning outcomes/competences
Students can enumerate the basic structural properties of biological macromolecules. They can explain the basic principles of the methods used in the practical course; That is, they are able to explain the applied physical laws with regard to thermodynamics, kinetics and spectroscopy. With the help of the acquired knowledge, students are able to evaluate the learned methods with regard to their applicability to certain biological questions, to compare advantages and disadvantages and to critically interpret measurement results.
The students can handle measuring instruments and equipment from the laboratory independently and precisely. They have learned to prepare samples for biophysical measurements taking into account the respective requirements, to record the measurement data in the required quality and quantity adapted to the device-typical requirements, to evaluate them using the software provided and to display them graphically. They can interpret the results obtained in terms of their significance, accuracy and in larger contexts.
The students are able to transfer these acquired skills to new, scientific questions, i.e. to independently plan and carry out biophysical experiments and to critically interpret the results.

Forms of teaching
Lecture, practical course, lab protocol, seminar

Contents
Lecture
- Fundamentals of thermodynamics (main theorems, van't Hoff equation, Langmuir's adsorption isotherms, electrophoretic mobility shift analysis)
- Reaction kinetics (rate equation, reaction order, time laws, Arrhenius and Eyring equations, measurement methods)
- Spectroscopy of absorption, fluorescence, circular dichroism (CD)
- Hydrodynamics
- Fluorescence correlation spectroscopy (FCS)
- Atomic force microscopy (AFM)

Practical course
- Purification of proteins (column chromatography)
- Fluorescence labeling
- Stopped-flow (intercalation into nucleic acid, protein folding)
- Protein conformation rearrangement via CD
- Determination of binding constants (Langmuir, FCS, analytical ultracentrifugation)
- AFM
- Temperature gradient gel electrophoresis and PCR

Prerequisites

Formal:	Admission to the master's programme
Content:	Computing and physics for scientists, basic knowledge regarding the structure of biological macromolecules

Type of examination

1. Knowledge competence area (70% of the grade): Oral examination on the contents of the lecture and the practical course; Duration: 30 minutes
2. Documentation competence area (20% of grade): Protocol (evaluation and discussion of scientific experiments); Length of the protocol: approx. 60 pages
3. Competence area scientific presentation (10% of the grade): Seminar lecture (development of the material, graphic representation of the contents, lecture, discussion); Duration: 20 minutes

Prerequisites for the award of credit points

(1) Regular and active participation in the practical course
(2) Passing the competence area knowledge and scientific presentation, documentation
(3) Submission of a protocol that meets the requirements of scientific documentation

Assignment to specialisation field

D) Bioinformatics, structure & diagnostics

Module applicability in other study courses

Master Biology, Master Biochemistry

Assessment

The grade is weighted according to the credit points (CP) in the overall grade
MSc Molecular Biomedicine 14/72 CP.

Language of instruction

German and English (Original papers for seminar in English)

Further information

The module is assigned centrally.

M4530 Structural biology: folding, misfolding and aggregation at high resolution

Strukturbiologie: Faltung, Fehlfaltung und Aggregation in Hochauflösung

Module convenor
Prof Dr Dieter Willbold (dieter.willbold@uni-duesseldorf.de); Prof Dr Henrike Heise (henrike.heise@hhu.de), Prof Dr C. Sachse (c.sachse@fz-juelich.de)

Lecturers
Dr M. Stoldt, Prof Dr Dieter Willbold, Prof Dr H. Heise, Prof Dr C. Sachse

Module organisation
Dr Matthias Stoldt (m.stoldt@fz-juelich.de)

Work load	Credit points	Contact time	Self study	Duration
420 h	14 CP	225 h	195 h	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Summer term	8 Students

Learning outcomes/competences
Students are able to explain, assess and apply the principles and basic concepts of structural biological, biophysical methods (NMR spectroscopy in liquid and solid phase and with cryo-electron microscopy including protein sample preparation) and apply them to biological systems with a focus on misfolding proteins.

Forms of teaching
Lecture, practical course, keeping minutes, preparation of seminar presentations

Contents
The module focuses on the investigation of amyloidogenic proteins using NMR spectroscopy and cryo-EM as well as the preparation of the necessary samples.
- Preparation of protein samples for NMR spectroscopy: heterologous expression of (fusion) proteins in isotope-enriched (13C, 15N) media. Protein purification on a mg scale.
- Liquid NMR: General principles of NMR spectroscopy, application of NMR-spectroscopy in biological questions.
Introduction: Recording of 1D experiments (ethanol, amino acids, proteins), processing and evaluation of the spectra. From 1D to 2D experiment, principle of indirect dimension, homonuclear and heteronuclear experiments.
Comparison of NMR spectra of globular folded proteins and intrinsically unstructured proteins.
Basics and recording of 3D triple resonance experiments, assignment strategy, (examples: HNCACB, HNCO). Backbone allocation; Assignment of 3D NOE spectra, extraction of structural parameters; further experimental data for structural calculation, molecular dynamics, strategy of "simulated annealing", example structure calculation, quality parameters.
Visualisation of protein structures & complexes, secondary structure, hydrophobic nucleus, tertiary contacts, electrostatic potential. - Solid-state NMR: General basics of solid-state NMR spectroscopy, Questions that can be addressed with this method, Various methods to achieve high resolution despite anisotropic line broadening: Magic Angle Spinning and macroscopic orientation. Structural information in the solid: torsion angles, dipolar couplings and chemical displacement anisotropy. Simulation software: SIMPSON and MATLAB, analysis software: nmrPipe, nmrDraw, CCPN. Objects of investigation: single amino acids in solid phase and smaller model peptides.

- Cryo-EM: strategy of sample preparation, negative contrast staining of protein samples with subsequent visualisation in the electron microscope, preparation of cryo-samples by plunge freezer and cryo-microscopy
Basics of image processing, Fourier transformation and image formation in the electron microscope
Image processing of molecular images of cryomicrographs, analysis of images and particle selection and 2D classification

3D image reconstruction and classification, structural interpretation of cryo-EM densities using atomic models
Prerequisites **Formal:** Admission to master´s programme **Content:** Basic knowledge of physical chemistry and basics of biochemistry are required. Interest in structural biology and physicochemical relationships is required.
Type of examination (1) Competence area knowledge (65% of the grade): Written examination (as a rule) on the contents of the lecture and the practical course; Duration: 60 minutes (2) Competence area documentation (20% of the grade): Protocol (topic, implementation, evaluation and discussion of scientific experiments); Volume: approx. 60 pages (3) Competence area scientific presentation (15% of the grade): Seminar lecture (development of the material, graphic representation of the contents, lecture, discussion); Duration: 20 minutes
Prerequisites for the award of credit points (1) Passing the competence area knowledge (2) Regular and active participation in the practical course (3) Submission of a protocol complying with the requirements of scientific documentation (4) Holding a seminar lecture that meets the minimum standards
Assignment to specialisation field D) Bioinformatics, structure & diagnostics
Module applicability in other study courses Master Biology, MSc Biology International
Assessment The grade is weighted according to the credit points (CP) in the overall grade: MSc Molecular Biomedicine 14/ 72 CP.
Language of instruction German
Further information The module is assigned centrally. Presence at the preliminary meeting is mandatory. The module takes place at Forschungszentrum Jülich (there is a shuttle bus between the campus of HHU Düsseldorf and FZ Jülich)

M4540 Molecular diagnostics

Molekulare Diagnostik

Modulverantwortlicher
Priv.-Doz. Dr Csaba Mahotka (mahotka@med.uni-duesseldorf.de)

Lecturers
Prof Dr Arndt Borkhardt, Prof Margitta Elvers, Dr Diran Herebian, Dr Till Hoffmann, PD Dr Csaba Mahotka, Prof Klaus Pfeffer, Prof Kai Stühler, Prof Jörg Timm, Dr Thorsten Trapp, Prof Dagmar Wieczorek, further lecturers and staff members

Module organisation
PD Dr Csaba Mahotka (mahotka@med.uni-duesseldorf.de)

Work load	Credit points	Contact time	Self study	Duration
420 h	14 CP	203 hrs	217 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 16 PPW Lecture: 2 PPW	Winter term	6 Students

Learning outcomes/competences
The practical course is aimed at students who aspire an occupation, professional qualification and, if necessary, entrepreneurial development in medical laboratory diagnostics. Students learn the competent application and interpretation of diagnostic analyses. Through internships in the various laboratory diagnostic institutes and laboratory units of the UKD a comprehensive overview of the practical application of molecular analysis in relevant areas of medical diagnostics is offered. Students gain direct insight into the practical implementation of molecular-diagnostic analyses and strategies. The accompanying lecture prepares the respective theoretical background and leads to a meaningful in-depth self study. An awareness and a concrete idea of different job profiles in the field of applied biomedicine, including the independent start-up, is brought about, on the basis of which further career planning can be envisaged.

Forms of teaching
Lecture with interactive parts and direct practical work
Self study with online materials, scripts, review articles and textbooks
Supervised laboratory internship in small groups

Contents
1. Proteomics: SRM analysis of biomarker proteins in cerebrospinal fluid
2. Tumour diagnostics: a.) NGS-based diagnosis of pediatric tumours as the basis of individualized tumour therapy; b.) In vivo models for the elucidation of etiopathogenesis of pediatric neoplasia; c.) Accompanying diagnostics cellular therapy procedures in (pediatric) oncology.
3. Metabolism: a) Acylcarnitine profiles from dried blood maps: (extraction, derivatisation, mass spectrometry, evaluation of results); b.) Plasma/dried blood card amino acid profile (extraction, derivatisation, mass spectrometry, evaluation of results); c.) Determination of orotic acid in urine by HPLC-UV.
4. Blood clotting: a.) Hemophilia as a natural model ('from genetic defect to coagulation factor deficiency'); b.) Molecular basis of specific hemotherapy; c.) Molecular diagnosis of allo- and autoimmune phenomena (i.e. hemophilia).
5. Platelet function: a.) Global and screening tests from whole blood; b.) laboratory tests for thrombocytopenia; c.) detection of platelet dysfunction; d.) Glanzmann thrombasthenia as an example of congenital platelet dysfunction.
6. Human genetics: diagnosis of rare hereditary diseases.
7. Transplantation diagnostics: a.) HLA diagnostics; b.) cell typing by flow cytometry; c.) Ethical aspects of diagnostic action and transplantation medicine
8. Molecular pathology: tumour diagnostics by means of mutation analyses (KRas/NRas, BRaf and EGFR), histochemistry.
9. Laboratory medicine: a.) Theoretical foundations of medical laboratory diagnostics; b.) autoimmune diagnostics; c.) geno-toxicological diagnostics; d.) Hematology.

10. Virology: Molecular and phenotypic resistance testing of viruses: a.) Molecular resistance testing of HIV and HCV; b.) Phenotypic resistance testing of CMV
11. Bacteriology: phenotyping and resistance determination of bacterial pathogens.
12. Biotechnology: Business start-ups in the biotech sector, principles and possibilities.

Prerequisites
Formal: Admission to Master´s programme Molecular Biomedicine
Content: Basic knowledge of common molecular biological and biochemical analysis techniques; general knowledge of biochemistry, cell biology, genetics; Interest in medical diagnostics and, if necessary, a career intention in this direction.

Type of examination
(1) Competence area knowledge (80% of the grade): Written or oral examination on the contents of the lecture and the practical course; Duration: 120 minutes
(2) Competence area scientific presentation (20% of the grade): Seminar lecture (development of the material, graphic representation of the contents, lecture, discussion); Duration: 30 minutes

Prerequisites for the award of credit points
(1) Successful self study
(2) Successful participation in the practical course
(3) Passing the final module examination

Assignment to specialisation field
D) Bioinformatics, structure & diagnostics

Module applicability in other study courses
None

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German

Further information
The module is assigned centrally. Presence at the preliminary meeting is mandatory.

M4560 Genome analysis in biomedical research

Genomanalyse in biomedizinischer Forschung

Module convenor
Prof Martin Lercher (martin.lercher@hhu.de) / Prof William Martin (w.martin@hhu.de)

Lecturers
Prof Alexander Dilthey, Prof Tobias Marschall, Prof William Martin, Dr Mayo Röttger

Module organisation
Dr Mayo Röttger (mayo.roettger@hhu.de)

Work load	Credit points	Contact time	Self study	Duration
420 hrs	14 CP	225 hrs	195 hrs	1 Semester

Courses	Frequency of offer	Group size
Practical course: 18 PPW Lecture: 2 PPW	Summer term	20 Students

Learning outcomes/competences
Students can name important algorithms of molecular sequence analysis and describe their theoretical background. Methods such as sequence search, alignment, clustering, as well as phylogenetic reconstruction are understood in detail and different solutions of these problems can be compared and the respective advantages and disadvantages, as well as the limitations of the methods can be explained.

Workflows for solving bioinformatic problems can be developed, implemented independently with the help of a learned programming language and the solutions critically commented. The students are able to break down complex problems into sub-problems and solve them in group work.

Students understand the targeted use of bioinformatic methods to solve problems of biomedical research practice (SARS-COV-2 surveillance).

The course participants know numerous biological databases. They know how to make targeted search queries and can also automate them, if necessary, with the help of the programming interfaces provided. The search results can be interpreted and their relevance assessed.

The course participants learn the programming language Python and know all essential commands and data structures, including helpful modules for statistical analysis of biological and biomedical data and their appealing graphical representation. You can dynamically adapt the techniques you have learned to the constantly changing methods of research at any time.

The students are able to analyze large amounts of data, extract relevant information and prepare it for subsequent analysis steps. Recurring workflows can be automated.

The methods used in research can be documented professionally and in detail in Jupyter notebooks within the flexible Jupyter Lab environment.

The learned methods and programming skills are applied to examples from biological and biomedical research.

You will learn to present a scientific publication.

Forms of teaching
Lecture or seminar-like lessons with practical exercises and seminar. Depending on the current situation, the course can also be conducted online without restrictions.

Contents

Studies on questions of biomedical research with the help of the programming language Python

Genomic SARS-COV-2 surveillance

Operation and operation of programs and program packages for the analysis of molecular sequence data (BLAST, alignment, phylogenetic trees and networks, bootstrapping, clustering)

Biological databases and use of provided programming interfaces

"Big data" analysis using the Python programming language

Introduction to the programming language Python (syntax, data structures, control structures, structured programming), as well as additional modules for computational molecular biology and scientific computing (Biopython, NumPy, SciPy, pandas).

JupyterLab and Jupyter Notebooks

Brief introduction to the Linux operating system

The course provides both theoretical background information and practical skills. Students perform practical exercises and discuss the results.

For further information, please consult the following Web address:
https://www.molevol.hhu.de/unsere-lehre/m-modul-4510-sommer-und-Winter term.html

Prerequisites
Formal: Admission to study programme Master Molecular Biomedicine
Content: None

Type of examination
1. Competence area knowledge (50% of the grade): Written examination on the contents of the lecture and the practical course; Duration: 60 minutes
2. Area of competence application of acquired knowledge (50% of the grade): Completion of practical tasks; Duration: 120 minutes

Prerequisites for the award of credit points
1. Regular and active participation in the module
2. Passing of the competence area knowledge
3. Passing the competence area application of acquired knowledge
4. Regular participation in the seminar and giving a seminar lecture

Assignment to specialisation field
D) Bioinformatics, structure & diagnostics

Module applicability in other study courses
Master Biology

Assessment
The grade is included in the overall grade according to the credit points (CP):
MSc Molecular Biomedicine 14/72 CP.

Language of instruction
German and English

Further information
The module is assigned centrally. Presence at the preliminary meeting is mandatory.

7000 Additional qualifications (compulsory elective)

Zusatzqualifikationen (Wahlpflicht)

Module convenor
Prof Sebastian Wesselborg (sebastian.wesselborg@uni-duesseldorf.de)

Lecturers
various

Module organisation
Annette Eder-Martin (Mol-Biomed@HHU.de)

Work load	Credit points	Contact time	Self study	Duration
300 h	10 CP			1 Semester

Courses	Frequency of offer	Group size
All free accessible courses/classes of all faculties and institutions of HHU	Every semester	

Learning outcomes/competences
Students acquire additional qualifications amounting to 10 credit points (10 CP) depending on the chosen courses and classes. They are able to familiarise themselves with the respective topics, they know the contents taught, they can justify their choice of courses/classes and write a summary (Reflexion) about it.

Forms of teaching
Forms of teaching depend on courses/classes taken

Contents
Contents depend on courses/classes taken

Prerequisites
Formal: Admission to Master´s programme Molecular Biomedicine
Content:

Type of examination
Written summary, ungraded; Volume: min. 2 pages

Prerequisites for the award of credit points
Submission of a written summary (Reflexion) to coordinator (E-mail: mol-biomed@HHU.de)

Assignment to specialisation field

Module applicability in other study courses

Assessment
The module is ungraded.

Language of instruction
German and English

Further information
Examples of additional qualifications: Animal Experimentation Course with acquisition of FELASA-B certificate: 6 CP, registration with coordination (Mol-Biomed@HHU.de); Laboratory rotation: 1 to 6 weeks stay per laboratory (1.5 CP per week); All offers of the student academy, registration via LSF "Veranstaltungsverzeichnis/Studierendenakademie"; Lectures: 15 lectures of 45 minutes each = 1 CP (proof of attendance required); Seminars: CP according to certificate of attendance; Further information in ILIAS in folder “Zusatzqualifikationen”

5500 Practical internship (compulsory)

Projektpraktikum (Pflicht)

Module convenor
All authorized lecturers of the Master's programme Molecular Biomedicine

Lecturers
All authorized lecturers of the Master's programme Molecular Biomedicine

Module organisation

Work load	Credit points	Contact time	Self study	Duration
600 h	20 CP			1 Semester

Courses	Frequency of offer	Group size
Research internship	Every semester	1 Student

Learning outcomes / competences
The practical **i**nternship is a 12-week all-day research internship and serves to illustrate the research activities in the working groups. Students are entrusted with a specific project on which they work under individual supervision. This can also be a preparation for a possible master's thesis topic. Research internships are an ideal time for a stay abroad.

Forms of teaching
Research internship

Contents
Depending on the institute or working group

Prerequisites
Admission to master´s programme and depending on the institute or working group

Type of examination
Ungraded colloquium (presentation of the test results and concluding scientific discussion); Duration: 30 minutes

Prerequisites for the award of credit points
Regular participation in the research internship, submission of a lab protocol and passing the final module examination

Module applicability in other study courses

Assessment
The module is not graded.

Language of instruction
German and English

Further information
Registration directly with the institutes or working groups; Further information available in ILIAS in the folder "Projektpraktikum"

5600 Pilot thesis (compulsory)

Pilotarbeit (Pflicht)

Modul conventor
All authorized lecturers of the Master's programme Molecular Biomedicine

Lecturers
All authorized lecturers of the Master's programme Molecular Biomedicine

Module organisation
Alle prüfungsberechtigten Dozenten/innen des Masterstudiengang Molecular Biomedicine

Work load	Credit points	Contact time	Self study	Duration
300 hrs	10 CP			1 Semester

Courses	Frequency of offer	Group size
Research internship Seminar	Every semester	1 Student

Learning outcomes/competences
The pilot thesis is a research internship and serves as a prelude to the master's thesis, at the end of which a written concept (project outline) for the implementation of the master's thesis is created. Students complete an 8-week laboratory phase with mandatory participation in the institute/group seminars. After the module, students will be able to carry out an experimental master's thesis independently.

Forms of teaching
Research internship, seminar, project outline for the master thesis

Contents
Depending on the institute or working group

Prerequisites
Admission to master´s programme and depending on the institute or working group

Type of examination
Ungraded colloquium (presentation of the experimental results and the project outline for upcoming master's thesis as well as concluding scientific research discussion); Duration: 30 minutes

Prerequisites for the award of credit points
Participation in the institute seminar, presentation of own results/data within the seminar and a final written project outline for the upcoming master's thesis

Assignment to specialisation field

Module applicability in other study courses

Assessment
The module is not graded.

Language of instruction
German and English

Further information
Registration directly with the institutes or working groups; further information available in ILIAS in the folder "Pilotarbeit"

6000 Master´s thesis (compulsory)

Masterarbeit (Pflicht)

Module convenor
All authorized lecturers of the Master's programme Molecular Biomedicine

Lecturers
All authorized lecturers of the Master's programme Molecular Biomedicine

Module organisation
Supervisor

Work load	Credit points	Contact time	Self study	Duration
900 hrs	30 CP			1 Semester

Courses	Frequency of offer	Group size
	Every semester	1 Student

Learning outcomes/competences
The master's thesis is intended to show that the candidate is able to independently work on a scientific question of significant novelty value in the field of molecular biomedicine using scientific methods within a defined period of time.

Forms of teaching
Independent practical research work, progress reports/lectures, thesis, final lecture (colloquium)

Contents
The master's thesis is a 6-month experimental work in the field of molecular biomedicine; Research topic depending on the institute or working group

Prerequisites
Formal: The master's thesis can only be registered when 80 CP have been reached.
Content: Depending on the institute or working group

Type of examination
Written elaboration of experimental results (master's thesis, 100% of the grade); Volume: maximum 80 pages
Colloquium (ungraded); Duration: 30 minutes

Prerequisites for the award of credit points
(1) Timely submission of written work (master's thesis)
(2) Colloquium

Assignment to specialisation field

Module applicability in other study courses

Assessment
The grade is weighted according to the credit points (CP) in the overall grade:
MSc Molecular Biomedicine 30/72 CP.

Language of instruction
German and English

Further information
Registration directly with the institutes or working groups; further information in ILIAS in the folder "Masterarbeit"