Friedrich-Alexander-Universität
Degree program Molecular Medicine | M.Sc.

Module handbook

of the study program

Molecular Medicine, Master of Science

Version 2024/2025

Index

General Information

The master's program in Molecular Medicine at FAU Erlangen-Nürnberg starts in the winter term. The usual period for completing the M.Sc. is two years (4 semesters), after which a Ph.D. program can be started. The master's program is based on the bachelor's program "Molekulare Medizin" at FAU and provides an advanced education with the goal of preparing students for a career in biomedical research. All courses of the master's program are given in English.

To enter the master's program, applicants must have completed a subject specific bachelor's degree with high academic standing from a recognized university.

The master's program includes compulsory, elective compulsory and elective modules. The master's thesis is completed during the fourth semester. All modules add up to 120 ECTS credit points.

An external stay of up to six months duration – preferentially abroad - is suggested for all students.

Examination Regulations

https://www.fau.de/universitaet/rechtsgrundlagen/pruefungsordnungen/

Feldfunktion geändert

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Abbreviations

L	Lecture
T	Tutorial
S	Seminar
P	Practical Training
FAU	Friedrich-Alexander-University Erlangen-Nürnberg

Curriculum

Curricular Categories and Module Names	ECTS	Semester
Area 1 – Compulsory subjects	**35**	
Advanced Lectures in Molecular Medicine 1	10	1.
Laboratory Animal Science and Biological Safety	5	1.
Architecture of Biopolymers	5	1.
Advanced Lectures in Molecular Medicine 2	10	2.
Research Design	5	2.
Area 2 – Elective compulsory subjects A	**30**	
Elective Module A	5	1.
Elective Compulsory Seminar Module 1	5	1.
Elective Compulsory Seminar Module 2	5	2.
Elective Compulsory Seminar Module 3	5	3.
Project Development	10	3.
Area 3 – Elective compulsory subjects B	**25**	
External Module/s, Laboratory Research Modules	25	2.+3.
Area 4 – Master‘s thesis	**30**	
Master’s thesis	25	4.
Master’s colloquium	5	4.
Total	**120**	

Area 1 – Compulsory subjects

Curricular Category and Module Names	ECTS	Semester	
1700 - Compulsory subjects	**35**		**Area grade**
22430 - Advanced Lectures in Molecular Medicine 1	10	1.	Graded
22451 - Laboratory Animal Science and Biological Safety	5	1.	Pass/fail
22440 - Architecture of Biopolymers	5	1.	Graded
22435 - Advanced Lectures in Molecular Medicine 2	10	2.	Graded
22446 - Research Design	5	2.	Graded

The area grade is calculated as the average of the modules weighted by the modules' ECTS points. The area 1 grade contributes approx. 29% to the final master's grade (35/120 ECTS).

1	Module name	**22430 - Advanced Lectures in Molecular Medicine 1**	**10 ECTS**
2	Courses/lectures	V: Immunology (2 SWS) V: Molecular Neuroscience (2 SWS) V: Molecular Imaging (2 SWS)	
3	Lecturers	Prof. Bogdan, Prof. Vöhringer, Prof. Dudziak, Prof. Alzheimer, Prof. Enz, Prof. Winkler, Prof. Lie, Prof. Bäuerle and others	
4	Module coordinator	Prof. Enz ~~Lecture coordinators: Prof. Bogdan (Immunology), Prof. Enz (Neuroscience), Prof. Lie (Imaging)~~	
5	Contents	**Lecture: Immunology** (Prof. Bogdan and others) Mechanisms, models and concepts • Evolution, components, function and dysfunction of the immune system • Anti-infectious immune response: innate, T and B cell-mediated immunity • Termination of the immune response, resolution of inflammation and tissue repair • Tumor immunology Medical aspects • Allergies, autoimmunity, chronic inflammatory and autoinflammatory diseases, immunodeficiencies, graft vs. host disease • Immunotherapy, antibodies and vaccination Specific techniques and methods in immunology **Lecture: Molecular Neuroscience** (Prof. Enz and others) Mechanisms, models and concepts • Neurocytology and synapses • Learning, memory, dementia and sleep • Sensory systems: Pain, Hearing, Vision • Plasticity in the central nervous system • Brain development Medical aspects • Neurodegenerative diseases and stroke • Psychiatric diseases Specific techniques and methods in neuroscience **Lecture: Molecular Imaging** (Prof. Lie and others) Mechanisms, models and concepts Principles of imaging and manipulation of cell-biological und molecular processes Medical aspects Preclinical models for human diseases (CNS Diseases, Oncology) Specific techniques and methods in molecular imaging • optical imaging • transgenic reporters for optical imaging • Magnetic Resonance Imaging • SPECT und PET • Optogenetics	
6	Learning objectives and skills	The students • obtain profound knowledge in the above described contents.	

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		• understand principle molecular and cellular mechanisms and their interplay in the nervous and immune systems. • understand basic and state-of-the-art concepts in imaging of biomedically relevant molecular and cell biological processes. • transfer obtained theoretical and methodological knowledge to research projects and to clinical settings including molecular therapies and diagnostics.
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine
8	Integration in curriculum	Compulsory module, 1st semester
9	Module compatibility	M. Sc. Molecular Medicine
10	Method of examination	24301 - Written exam, 180 min, open questions and multiple choice
11	Grading procedure	100 % grade of the written exam
12	Module frequency	Annually in the winter term
13	Resit examination	~~T~~Three times ~~wice~~
14	Workload	Class time: 90h Study time: 210 h
15	Module duration	1 term
16	Teaching and examination language	English
17	Recommended reading	**Immunology** Cellular and Molecular Immunology, eds. Abbas, Lichtman and Pillai, Elsevier-Saunders, newest edition; Janeway´s Immunobiology, eds. Murphy, Travers and Walport, Garland Science, newest edition **Neuroscience** Principles in Neural Science, Ed. Kandel, Schwartz, Jessel, Mc Graw Hill Basic Neurochemistry, Ed. Siegel, Albers, Brady, Price, Academic Press newest editions **Imaging** Weissleder et al., Molecular Imaging, People's Medical Publishing House, newest edition

1	Module name	**22440 - Architecture of Biopolymers**	**5 ECTS**
2	Courses/lectures	S: Architecture of Biopolymers (2 SWS) **Mandatory Attendance** T: Computer-based tutorial to Architecture of Biopolymers (2 SWS)	
3	Lecturers	Prof. Sticht and others	
4	Module coordinator	Prof. Sticht	
5	Contents	Mechanisms, models and concepts • Principles of protein structure and its role for protein function. • Alterations of protein structure and emergence of disease. • Elements of protein structure • Effect of mutations on protein stability and function Specific techniques and methods in structural biochemistry with medical aspects • Computational analysis of biomolecular structures and of disease-associated protein mutations. • Methods for structure determination • Protein databases and their respective data formats • Methods for *in silico* data analysis • Structures of medically important protein classes (e.g. kinases, proteases, nucleic acid binding, or transmembrane proteins) • Linear sequence motifs and protein interaction domains • Post-translational modifications • Protein (mis-)folding and aggregation • Protein design • Visualization of molecular structures • Analysis of interacting molecular surfaces	
6	Learning objectives and skills	The students • gain insight into the structural principles of biopolymers and their implications on function • acquire profound and hands-on knowledge of important concepts, databases, tools, and methods in structural and computational biology • are able to describe and to apply these methods to related problems in the field of structural biology • present and critically discuss scientific findings in seminar talks • gain experience with a toolset of computational methods and visualization programs that they can apply to their further studies and research projects Acquisition of the discussion skills requires continuous participation because the discussed topics build on the knowledge that is gained during the seminars.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Compulsory module, 1st semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24401 - Presentation with discussion (approx. 30 min) 24402 - Written exam, 60 min, multiple choice questions	

11	Grading procedure	100 % g~~G~~rade of the written exam
12	Module frequency	Annually in the winter term
13	Resit examination	~~Twice~~Three times
14	Workload	Class time: 60 h Study time: 90 h
15	Module duration	1 term
16	Teaching and examination language	English
17	Recommended reading	Literature provided on the institute's homepage: http://www.biochem.uni-erlangen. de/studium/index.php „Downloads Biopolymers" (password needed)

1	Module name	**22451 - Laboratory Animal Science and Biol. Safety**	**5 ECTS**
2	Courses/lectures	L: Laboratory Animal Science including Welfare (1 SWS) **Mandatory Attendance** P: Animal techniques for persons carrying out animal experiments **or** Alternative Techniques to replace animal experiments (1.5 SWS) **Mandatory Attendance** L: Biological Safety (1 SWS)	
3	Lecturers	Prof. von Hörsten, Dr. Schwarz, Dr. Jurgons, Dr. Schulze-Krebs, Prof. Boßerhoff and others	
4	Module coordinator	Prof. S. von Hörsten	
5	Contents	**Animal Care and Protection** • Relevant legal provisions (national and international) • Ethical aspects of working with laboratory animals • The 3R principle: "replace, reduce, refine" • Alternative techniques to replace animal experiments • Biology and housing of the most important laboratory animal species • Physiological requirements • Diseases of laboratory animals, zoonoses, hygiene in animal housing • Assessment of stress and measures for the avoidance of pain and sufferance • Planning and theoretical execution of animal experiments • Behavior of laboratory animals and species-appropriate handling • Administration of substances • Techniques of sample withdrawal • Killing techniques • Anesthesiology, analgesia and basic principles of surgery Students who are involved in approved animal experimentations can obtain a certificate for persons carrying out animal experiments (FELASA Category B) ("Fachkundenachweis nach den FELASA B Richtlinien"). **Biological Safety** • Risk potential of working with genetically modified organisms (GMO) • Risk potential of GMOs release • Legal provisions and security measures for laboratories and divisions working with GMOs • Health and safety measures Students can obtain the „Fachkundenachweis Projektleiter für die Biologische Sicherheit nach §15 und S17 GenTSV".	
6	Learning objectives and skills	The students • know and understand the legal prerequisites for working with laboratory animals and genetically modified organisms • reflect the ethical aspects of animal testing and genetic engineering • become acquainted and trained in animal handling and standard laboratory animal techniques (mouse, rat, large animal) Participation in the lectures and practical parts enables the students to adhere to legal regulations for safety measures and animal protection. Continuous participation is a legal requirement.	

7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine
8	Integration in curriculum	Compulsory module, 1st semester
9	Module compatibility	M. Sc. Molecular Medicine
10	Method of examination	24511 - Written exam, 120 min
11	Grading procedure	Pass/fail
12	Module frequency	Annually in the winter term
13	Resit examination	~~Twice~~Three times
14	Workload	Class time: 52,5~~0~~ h Study time: ~~110~~97,5 h
15	Module duration	1 term
16	Teaching and examination language	English
17	Recommended reading	Script „Animal Care and Protection“ Grundlagen der Versuchstierkunde, van Zutphen, Baumans, Beynen, neueste Auflage, Gustav Fischer ISBN 3-437-20532-3

1	Module name	**22435 - Advanced Lectures in Molecular Medicine 2**	**10 ECTS**
2	Courses/lectures	L: Molecular Oncology (2 SWS) L: Molecular Embryology (2 SWS) L: Molecular Genetics and Systems Medicine (2 SWS)	
3	Lecturers	Prof. Boßerhoff, Prof. Brabletz, Prof. Meder, Prof. Stürzl, Prof. Wegner, Prof. Engel, Prof. Reis, Prof. Winterpacht, Prof. Vera-Gonzalez and others	
4	Module coordinator	Prof. Wegner ~~Lecture coordinators: Prof. Meder (Oncology), Prof. Wegner (Embryology), Prof. Reis (Genetics and Systems Medicine)~~	
5	Contents	**Molecular Oncology** (Prof. Meder and others) Mechanisms, models and concepts • General tumor cell biology, oncogenes and tumor suppressor genes • Oncogenic signaling pathways, cell cycle and regulation of cell death • Transcription and epigenetics, genome integrity • Metabolomics and cancer • Multistep tumorigenesis • Tumor microenvironment, invasion and metastasis • Concept of tumor stem cells • Tumor angiogenesis and immunology Medical aspects • Molecular therapies • Molecular classification • Molecular diagnosis Specific techniques and methods in molecular oncology **Molecular Embryology** (Prof. Wegner and others) Mechanisms, models and concepts • Principles of human development • Developmental principles of biomedically relevant model organisms • Intrinsic and extrinsic regulatory pathways of development • Early embryonic development of C. elegans, D. melanogaster and vertebrates • Axis formation, germ layer formation, sex determination • Mesodermal development, ectodermal and neural crest development Medical aspects • inborn errors of development as cause of disease • malformations and syndromes • pleiotropy Specific techniques and methods in molecular embryology **Molecular Genetics and Systems Medicine** (Prof. Reis and others) Mechanisms, models and concepts • Modulation of penetrance in Mendelian diseases • Molecular basis of complex diseases • Epigenetic mechanisms • Gene - and genome regulation • Genetic approaches using animal models • Statistical interpretation of large data sets	

		• Quantitative trait loci • Analysis, reconstruction and modelling of biological systems and networks Medical aspects • genetic and epigenetic changes underlying human disease • physiology / pathophysiology of genetically determined biological processes Specific techniques and methods in molecular genetics and systems medicine
6	Learning objectives and skills	The students • gain knowledge in the above-mentioned contents. • Understand basic and modern concepts of biochemical systems, molecular and cellular oncology, molecular embryology and molecular genetics. • gain insight into the mechanisms underlying development and selected developmental disorders, tumor biology, genetic and epigenetic misregulation in selected disorders. • transfer theoretical and methodological knowledge to research projects and to clinical settings including molecular therapies and diagnostics. • utilize biostatistical methods and operate standard software tools for network and data analyses. • develop, interpret, evaluate and discuss biochemical networks and statistical analyses of biological data.
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine
8	Integration in curriculum	Compulsory module, 2nd semester
9	Module compatibility	M. Sc. Molecular Medicine
10	Method of examination	24351 - Written exam, 180 min, open and multiple-choice questions
11	Grading procedure	100 % g~~G~~rade of the written exam
12	Module frequency	Annually in the summer term
13	Resit examination	~~Twice~~Three times
14	Workload	Class time: 90 h Study time: 210 h
15	Module duration	1 term
16	Teaching and examination language	English
17	Recommended reading	**Oncology** Robert A. Weinberg, The Biology of Cancer, 2nd edition, Garland Science **Embryology** Selected chapters from Scott F. Gilbert: Developmental Biology (Sinauer Press) or Lewis Wolpert: Principles of Development (Oxford University Press) **Molecular Genetics** Selected chapters from Tom Strachan and Andrew Read: Human Molecular Genetics (Garland Science) or Tom Strachan et al.: Genetics and Genomics in Medicine (Garland Science)

1	Module name	**22446 - Research Design**	**5 ECTS**
2	Courses/lectures	S: Project and Proposal Design (3 SWS) **Mandatory Attendance**	
3	Lecturers	Prof. Brabletz, Prof. Lie, Prof. Stürzl and others	
4	Module coordinator	Prof. Lie	
5	Contents	Development of scientific projects Grant/paper writing strategies Good scientific practice	
6	Learning objectives and skills	The students • are able to perform literature searches and to critically summarize the state of the art • apply the obtained knowledge to generate scientific hypotheses • learn how to develop and formulate a scientific research program to test these hypotheses adhering to the rules of good scientific practice • acquire skills in scientific writing of research papers, project plans and grants • present and discuss project proposals in subgroups~~in oral presentations~~ Proposal writing is a group exercise in groups of approx. 5 students. To guarantee equal contribution to the group work attendance is mandatory. Further, acquisition of the scientific skills requires continuous participation.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Compulsory module, 2nd semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24461 - Written proposal, 10-15 pages	
11	Grading procedure	100 % ~~G~~grade of the term paper	
12	Module frequency	Annually in the summer term	
13	Resit examination	~~Twice~~Three times	
14	Workload	Class time: 45h Study time: 105h	
15	Module duration	1 term	
16	Teaching and examination language	English	
17	Recommended reading	Booklet “Safeguarding Good Scientific Practice” (DFG)	

Area 2 – Elective compulsory subjects A

Curricular Category and Module Names	ECTS	Semester	
1800 - Elective compulsory subjects A	**30**		**Area grade**
Choice of one seminar in each module			
1810 - Seminar Module 1: A1.1, A1.2 OR A1.3 22460 - A1.1 Molecular Genetics and Genomics 22465 - A2.1 Molecular Microbiology and Immunology of Infection 22470 - A3.1 Molecular Imaging	5	1.	Graded
1820 - Seminar Module 2: A2.1, A2.2 OR A2.3 22475 - A2.1 Molecular Neuroscience 22480 - A2.2 Essential Concepts in Modern Virology 22485 - A2.3 Molecular and Translational Concepts of Cardiac and Renal Disease	5	2.	Graded
1830 - Seminar Module 3: A3.1, A3.2 OR A3.3 22490 - A3.1 Molecular Oncology 22495 - A3.2 Current Concepts of Immunology 22499 - A3.3 Animal Models in Biomedical Research	5	3.	Graded
1835 - Elective Module A	5	1.	Pass/fail
22425 - Project Development	10	3.	Graded

The area grade is calculated as the average of the modules weighted by the modules' ECTS points. The area 2 grade contributes 25% to the final master's grade (30/120 ECTS).

1	Module name	**22460 - A1.1 Molecular Genetics and Genomics**	**5 ECTS**
2	Courses/lectures	S: Molecular Genetics and Genomics (2 SWS) **Mandatory Attendance**	
3	Lecturers	Prof. Reis, Prof. Winterpacht and others	
4	Module coordinator	Prof. Reis	
5	Contents	The students present and discuss basic principles of molecular genetics and genomics using selected key publications from scientific journals. The seminar covers the following aspects: • Mechanisms of gene regulation • Genomic architecture and phenotypic variability • Whole genome sequencing approaches for understanding genetic variation • Molecular basis of complex diseases • Molecular mechanisms of epigenetic regulation and inheritance • Animal models in dissecting genetic components of complex traits • Interpretation of large genomic data sets	
6	Learning objectives and skills	The students • obtain profound subject-specific knowledge in molecular genetics and genomics • obtain skills for a critical analysis and interpretation of scientific data • read, present and analyze current primary scientific literature • independently solve problems in the field of molecular genetics and present their solutions in oral and written form • train their ability for discussion and teamwork by working in small groups • give and receive critical feedback to and from fellow students Acquisition of discussion, teamworking and feedback skills in courses with 8-10 participants requires continuous presence of all participants.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 1st semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24601 - Presentation, 30 min (pass/fail) 24602 - Term paper, 15-20 pages (graded)	
11	Grading procedure	~~G~~100% grade of the term paper	
12	Module frequency	Annually in the winter term	
13	Resit examination	~~Twice~~Three times	
14	Workload	Class time 30 h Study time 120 h	
15	Module duration	1 term	
16	Teaching and examination language	English	
17	Recommended reading	Tom Strachan et al.: Genetics and Genomics in Medicine (Garland Science), newest edition	

1	Module name	**22465 - A1.2 Molecular Microbiology and Immunology of Infection**	**5 ECTS**
2	Courses/lectures	S: Microbiology and Immunology of Infection (2 SWS) **Mandatory Attendance**	
3	Lecturers	Prof. Vöhringer, Prof. Krappmann, Prof. Lührmann and others	
4	Module coordinator	Prof. Bogdan	
5	Contents	The students present and discuss basic principles of host-pathogen interactions, cellular and molecular regulation of immune responses, defense mechanisms against pathogens and molecular escape strategies using selected key publications from scientific journals. The seminar covers the following aspects: • Adhesion and invasion of pathogens • Bacterial secretion systems • Modulation of intracellular transport of proteins and vesicles • Bacterial toxins • Pathogen recognition and innate immunity • Diversity, plasticity and function of T helper cells • Antiviral functions of CD8 T cells • Innate lymphoid cells • Fungal pathogens and secondary metabolites of fungi • Pathogenicity of helminths • Immune response to fungi, helminths and protozoan infections • Immune evasion of infectious pathogens, pathogen persistence	
6	Learning objectives and skills	The students • obtain profound subject-specific knowledge in molecular microbiology and immunology of infection. • obtain skills for a critical analysis and interpretation of scientific data. • read, present and analyze current primary scientific literature • independently solve problems in the field of microbiology and immunology of infection and present their solutions in oral and written form • train their ability for discussion and teamwork by working in small groups • give and receive critical feedback to and from fellow students Acquisition of discussion, teamworking and feedback skills in courses with 8-10 participants requires continuous presence of all participants.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 1st semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24651 - Presentation, 30 min (pass/fail) 24652 - Term paper, 15-20 pages (graded)	
11	Grading procedure	100 % g~~G~~rade of the term paper	
12	Module frequency	Annually in the winter term	

13	Resit examination	~~Twice~~Three times
14	Workload	Class time 30 h Study time 120 h
15	Module duration	1 term
16	Teaching and examination language	English
17	Recommended reading	**1. General** • Schaible et al. Intracellular Niches of Microbes: a Pathogens Guide Through the Host Cell (1st ed. 2009); • Salyers and Witt: Bacterial Pathogenesis (3rd ed. January 2011) • Kaufmann, Rouse, Sacks: The Immune Response to Infection (1st ed. 2011); • Abbas, Lichtman, Pillai Cellular and Molecular Immunology, 8th ed. 2015 **2. Specific** primary literature (original articles, review articles) will be handed out

1	Module name	**22470 - A1.3 Molecular Imaging**	**5 ECTS**
2	Courses/lectures	S: Molecular Imaging (2 SWS) **Mandatory Attendance**	
3	Lecturers	Prof. Lie, Prof. Bäuerle and others	
4	Module coordinator	Prof. Lie	
5	Contents	The students present and discuss basic principles of key methods in molecular imaging using selected key publications from scientific journals. The students are introduced to theoretical and practical aspects of • optical imaging methods • small animal imaging • transgenic reporter design	
6	Learning objectives and skills	The students • obtain profound subject-specific knowledge in molecular imaging. • obtain skills for a critical analysis and interpretation of scientific data. • read, present and analyze current primary scientific literature. • transfer theoretical knowledge in imaging technologies to research projects. • judge the technological requirements of biomedical imaging methods and present their solutions in oral and written form. • get experience in preparing probes for biomedical imaging. • train their ability for discussion and teamwork by working in small groups. • give and receive critical feedback to and from fellow students. Acquisition of discussion, teamworking and feedback skills in courses with 8-10 participants requires continuous presence of all participants.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 1st semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24701 - Presentation, 30 min (pass/fail) 24702 - Term paper, 15-20 pages (graded)	
11	Grading procedure	100 % g~~G~~rade of the term paper	
12	Module frequency	Annually in the winter term	
13	Resit examination	~~Twice~~Three times	
14	Workload	Class time: 30 h Study time: 120 h	
15	Module duration	1 term	
16	Teaching and examination language	English	
17	Recommended reading	Weissleder et al., Molecular Imaging, People's Medical Publishing House, newest edition	

1	Module name	**22475 - A2.1 Molecular Neuroscience**	**5 ECTS**
2	Courses/lectures	S: Molecular Neuroscience (2 SWS) **Mandatory Attendance**	
3	Lecturers	Prof. Alzheimer, Prof. Enz, Prof. Kornhuber, Prof. Winkler, Prof. Wegner and others	
4	Module coordinator	Prof. Enz	
5	Contents	Students present and discuss basic principles of neuroscience using selected key publications from scientific journals. The seminar covers the following aspects: • Molecular principles of synaptic neurotransmission • Higher brain functions (e.g. learning and memory, dementia, sleep) • Sensory systems • Plasticity in the central nervous system • Molecular causes of disorders in the nervous system (e.g. blindness, neuro-degenerative diseases, depression, addiction, stroke) • Glial biology and disease • Muscle biology and disease • Presentation of patients in the neurology department	
6	Learning objectives and skills	The students • obtain profound knowledge in molecular and clinical neuroscience. • obtain skills for a critical analysis and interpretation of scientific data. • read, present and analyze current primary scientific literature embedded within the up-to-date scientific and therapeutic background. • learn the design of experimental strategies and techniques suited to answer scientific questions and present their solutions in oral and written form. • train their ability for discussion and teamwork by working in small groups. • give and receive critical feedback to and from fellow student. Acquisition of discussion, teamworking and feedback skills in courses with 8-10 participants requires continuous presence of all participants.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 2nd semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24751 - Presentation, 30 min (pass/fail) 24752 - Term paper, 15-20 pages (graded)	
11	Grading procedure	100 % g~~G~~rade of the term paper	
12	Module frequency	Anually in the summer term	
13	Resit examination	~~Twice~~Three times	
14	Workload	Class time 30 h Study time: 120 h	
15	Module duration	1 term	
16	Teaching and examination language	English	

17	Recommended reading	Principles in Neural Science, Ed. Kandel, Schwartz, Jessel, Mc Graw Hill Basic Neurochemistry 7. Auflage, Ed. Siegel, Albers, Brady, Price, Academic Press

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1	Module name	**22480 - A2.2 Essential Concepts in Modern Virology**	**5 ECTS**
2	Courses/lectures	S: Essential Concepts in Modern Virology (2 SWS) **Mandatory Attendance**	
3	Lecturers	Prof. Überla, Prof. Marschall and others	
4	Module coordinator	Prof. Marschall	
5	Contents	Students present and discuss basic principles of molecular and medical virology using selected current and/or classical publications from scientific journals. • antiviral therapy and prophylaxis • vaccination strategies • tumorigenic transformation mediated by viruses • epigenetics of viral genomes • viral regulatory proteins • virus-based vectors • immune control of viral infections	
6	Learning objectives and skills	The students • obtain profound knowledge in molecular and medical virology. • obtain skills for a critical analysis and interpretation of scientific data. • read, present, analyze and evaluate current/classical primary literature. • learn the design of experimental strategies and techniques suited to answer scientific questions and present their solutions in oral and written form. • train their ability for discussion and teamwork by working in small groups. • give and receive critical feedback to and from fellow student. Acquisition of discussion, teamworking and feedback skills in courses with 8-10 participants requires continuous presence of all participants.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 2nd semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24801 - Presentation, 30 min (pass/fail) 24802 - Term paper, 15-20 pages (graded)	
11	Grading procedure	100 % g~~G~~rade of the term paper	
12	Module frequency	Annually in the summer term	
13	Resit examination	~~Twice~~Three times	
14	Workload	Class time: 30h Study time: 120h	
15	Module duration	1 term	
16	Teaching and examination language	English	
17	Recommended reading	Will be determined individually by preparing discussions with the specific tutors.	

1	Module name	**22485 - A2.3 Molecular and translational concepts of cardiac and renal disease**	**5 ECTS**
2	Courses/lectures	S: Molecular and translational concepts of cardiac and renal disease (2 SWS) **Mandatory Attendance**	
3	Lecturers	Prof. Engel, Prof. Korbmacher, Prof. Ludwig, PD Dr. Seidel, Prof. Volk	
4	Module coordinator	PD Dr. Seidel	
5	Contents	The students present and discuss basic principles of heart and renal diseases using selected key publications from scientific journals. • Molecular, pathophysiological and pathological causes, signaling cascades and mechanisms of human cardiac, renal and circulatory diseases including heart failure, cardiac arrhythmia, tubular and glomerular disease, renal failure and hypertension. • Up-to-date experimental approaches, techniques and translational concepts in physiology, pharmacology, pathology and experimental medicine.	
6	Learning objectives and skills	The students • obtain profound subject-specific knowledge and substantial expertise in understanding molecular mechanisms of disease development and progression. • obtain skills for a critical analysis and interpretation of scientific data. • read, present, analyze and evaluate current primary and review literature. • learn the design of experimental strategies and techniques suited to answer scientific questions and present their solutions in oral and written form. • train their ability for discussion and teamwork by working in small groups. • give and receive critical feedback to and from fellow student. Acquisition of discussion, teamworking and feedback skills in courses with 8-10 participants requires continuous presence of all participants.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 2nd semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24851 - Presentation, 30 min (pass/fail) 24852 - Term paper, 15-20 pages (graded)	
11	Grading procedure	100 % g~~G~~rade of the term paper	
12	Module frequency	Annually in the summer term	
13	Resit examination	Three times~~wice~~	
14	Workload	Class time: 30 h Study time: 120 h	
15	Module duration	1 term	
16	Teaching and examination language	English	
17	Recommended reading	The necessary literature, consisting of original and review articles will be supplied by the lecturers.	

1	Module name	**22490 - A3.1 Molecular Oncology**	**5 ECTS**
2	Courses/lectures	S: Molecular Oncology (2 SWS) **Mandatory Attendance**	
3	Lecturers	PD Dr. Bernkopf, Prof. Brabletz, Prof. Stürzl, Prof. Boßerhoff and others	
4	Module coordinator	PD Dr. Bernkopf	
5	Contents	The students present and discuss basic principles of molecular oncology and translational aspects using selected key publications from scientific journals. • oncogenes and tumor suppressor genes • oncogenic signaling pathways • molecular classification, diagnosis and therapies • animal models • tumor microenvironment • angiogenesis • tumor immunology	
6	Learning objectives and skills	The students • obtain profound subject-specific knowledge and substantial expertise in understanding molecular mechanisms of tumor development and progression. • obtain skills for a critical analysis and interpretation of scientific data. • read, present, analyze and evaluate current primary literature. • learn the design of experimental strategies and techniques suited to answer scientific questions and present their solutions in oral and written form. • train their ability for discussion and teamwork by working in small groups. • give and receive critical feedback to and from fellow student Acquisition of discussion, teamworking and feedback skills in courses with 8-10 participants requires continuous presence of all participants.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 3rd semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24901 - Presentation, 30 min (pass/fail) 24902 - Written exam, 90 min (graded)	
11	Grading procedure	100 % gGrade of the written exam	
12	Module frequency	Annually in the winter term	
13	Resit examination	Three timeswice	
14	Workload	Class time 30h Study time: 120 h	
15	Module duration	1 term	
16	Teaching and examination language	English	

17	Recommended reading	Robert A. Weinberg, The Biology of Cancer, 2nd edition, Garland Science

1	Module name	**22495 - A3.2 Current Concepts of Immunology**	**5 ECTS**
2	Courses/lectures	S: Immunology (2 SWS) **Mandatory Attendance**	
3	Lecturers	Prof. Mielenz, PD Dr. Schuh, Dr. Wittmann	
4	Module coordinator	PD Dr. Schuh (on interim basis)	
5	Contents	The students present and discuss important physiologic and pathologic processes in basic and clinical immunology using selected key publications from scientific journals. In an interactive round-table format, each student will develop together with the class the hypothesis, the experimental set-up, the key-experiment(s) and the overall take-home message of the respective publication.	
6	Learning objectives and skills	The students • obtain subject-specific knowledge in molecular, cellular and clinical immunology. • obtain skills for a critical analysis and interpretation of scientific data. • read, present, analyze and evaluate current primary literature. • learn the design of experimental strategies and techniques suited to answer scientific questions and present their solutions in oral and written form. • train their ability for discussion and teamwork by working in small groups. • give and receive critical feedback to and from fellow students. Acquisition of discussion, teamworking and feedback skills in courses with 8-10 participants requires continuous presence of all participants.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 3rd semester	
9	Module compatibility	MSc Molecular Medicine MSc Cell- und Molecular Biology (Department Biology) MSc Life Science Engineering (School of Engineering)	
10	Method of examination	24951 - Presentation, 30 min (pass/fail) 24952 - Moderation of round-table discussion (graded)	
11	Grading procedure	100 % g~~G~~rade of the moderation	
12	Module frequency	Annually in the winter semester	
13	Resit examination	Thre~~wic~~e times	
14	Workload	Class time: 30h Study time: 120 h	
15	Module duration	1 term	
16	Teaching and examination language	English	
17	Recommended reading	Janeway's Immunobiology, Garland Science, newest edition Immunology, Kuby, W. H. Freeman, newest edition Roitt's Essential Immunology, Wiley-Blackwell, newest edition	

1	Module name	**22499 - A3.3 Animal Models in Biomedical Research**	**5 ECTS**
2	Courses/lectures	S: Animal Models (2 SWS) **Mandatory Attendance**	
3	Lecturers	Prof. von Hörsten, Prof. Bäuerle and others	
4	Module coordinator	Prof. von Hörsten	
5	Contents	Students review present concepts in epidemiology, pathophysiology and treatment of major disease entities: cancer, neurodegenerative disorders, allergies, autoimmune diseases, metabolic disorders. Translation of specific disease and patho-mechanisms into an animal model is elaborated using selected key publications. The seminar covers animal models including zebrafish, rodents and larger mammals, for the investigation of diseases and therapeutic approaches in: • Neoplasia with focus on metastasis • Neurodegeneration incl. Alzheimer´s, Parkinson´s, and Huntington´s disease • Allergy including asthma and atopic dermatitis • Autoimmunity with specific reference to multiple sclerosis • Diabetes with focus on Type II diabetes Special emphasis will be given to systems interactions as well as limitations of animal models including but not limited to their standardization, suitability, and nature-nurture derived aspects in diseases and their models.	
6	Learning objectives and skills	The students • obtain profound subject-specific knowledge in animal testing and model based biomedical research approaches. • obtain skills for a critical analysis and interpretation of scientific data. • read, present and analyze current primary scientific literature. • independently develop hypothesis and research strategies and present their solutions in oral and written form. • train their ability for discussion and teamwork by working in small groups. • give and receive critical feedback to and from fellow students. Acquisition of discussion, teamworking and feedback skills in courses with 8-10 participants requires continuous presence of all participants.	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 3rd semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24991 - Presentation, 30 min (pass/fail) 24992 - Term paper, 15-20 pages (graded)	
11	Grading procedure	100 % g~~G~~rade of the term paper	
12	Module frequency	Annually in the winter term	
13	Resit examination	~~Twice~~Three times	
14	Workload	Class time: 30h Study time: 120 h	
15	Module duration	1 term	
16	Teaching and examination language	English	

Formatierte Tabelle

17	Recommended reading	Will be determined individually each semester.

hat formatiert: Englisch (Vereinigte Staaten)

1	Module name	**1835 - Elective Module**	**5 ECTS**
2	Courses/lectures	Depends on chosen module	
3	Lecturers	Depends on chosen module	
4	Module coordinator	Depends on chosen module	
5	Contents	The students choose from the courses offered at FAU • key qualifications • modules from other bachelor's and master's programs, depending on availability • seminars offered by the master's program The key qualifications are faculty-independent course offers that are not related to specific subjects, e. g. languages, communicational and presentational skills. Modules from other bachelor's and master's programs that are not listed as key qualifications can only be chosen with permission from the module coordinator. Elective modules in molecular medicine Additional seminars from the elective compulsory part of the master's program in molecular medicine depend on availability. Additional elective modules offered by the master's program are listed in the module manual. Additional research modules or internships need the approval of the study board.	
6	Learning objectives and skills	The students • can gain insight into diverse academic topics • can acquire soft skills that promote their employability • can broaden their general education • can gain expertise in specific subjects	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective module, 1st semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	Depend on chosen module	
11	Grading procedure	Pass/fail	
12	Module frequency	Every semester	
13	Resit examination	~~Twice~~Three times	
14	Workload	Depends on chosen module	
15	Module duration	1 term	
16	Teaching and examination language	Depends on chosen module	
17	Recommended reading	Depends on chosen module	

1	Module name	**22425 - Project Development**	**10 ECTS**
2	Courses/lectures	P: laboratory course (6 SWS) T: Journal Club (1 SWS)	
3	Lecturers	All lecturers of the master's program	
4	Module coordinator	Prof. Boßerhoff	
5	Contents	Laboratory training and development of a research project in preparation of the master's thesis. The module has a maximum duration of 6 weeks and is composed of: • a tutorial, in which the student and the advisor discuss possibilities of a research project based on the current literature • laboratory training for the collection of preliminary data • writing and presentation of a research proposal	
6	Learning targets and skills	The students • gain insight into a research topic of their choice and independently study the current literature • work and integrate themselves in established research groups • apply the rules of good scientific practice to experimentation, documentation and data analysis • utilize modern experimental techniques to collect scientific data and critically interpret their results • evaluate their data, compare them to published results and discuss their findings with the advisor(s) and the research group • develop a research plan for a six months master's project	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 3rd semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	24251 - Project plan, 5-10 pages (font: Arial, size: 11 pt, spacing: 1.5x) Proposed project and hypothesis (10 lines) Background (1/2-1 page) Preliminary data from the laboratory course (2-4 pages) Time table for the master's project (1/2 page), optional: Cost calculation (1 page) References (max. 10)	
11	Grading procedure	100 % g~~G~~rade of the project plan	
12	Module frequency	Each semester	
13	Resit examination	Three times~~wice~~	
14	Workload	Class time:105 h ~~and s~~ Study time: ~~300~~195 h	
15	Module duration	1 term	
16	Teaching and examination language	English	

17	Recommended reading	Individually defined by the advisor

Area 3 – Elective compulsory subjects B

Curricular Categories and Module Names	ECTS	Semester	
1840 - Elective compulsory subjects B	**25**		**Area grade**
Laboratory Training A, B, C, D, E OR F: choice of modules for 25 ECTS from the following			
External Modules for 10, 15, 20 or 25 ECTS			Graded
Research Modules at FAU for 10 or 15 ECTS			Graded
Elective Module B			Pass/fail
1850 - Laboratory Training A		2. + 3.	
22610 - External Module	25		Graded
1860 - Laboratory Training B		2. + 3.	
22615 - External Module	20		Graded
1836 - Elective Module B	5		Pass/fail
1870 - Laboratory Training C		2. + 3.	
22620 - External Module	15		Graded
22630 - Laboratory Research Module A	10		Graded
1880 - Laboratory Training D		2. + 3.	
22640 - Laboratory Research Module	15		Graded
22625 - External Module	10		Graded
1890 - Laboratory Training E		2. + 3.	
22630 - Laboratory Research Module A	10		Graded
22635 - Laboratory Research Module B	10		Graded
1836 - Elective Module B	5		Pass/fail
1895 - Laboratory Training F		2. + 3.	
22640 - Laboratory Research Module	15		Graded
22630 - Laboratory Research Module A	10		Graded

The area grade is calculated as the average of the modules weighted by the modules' ECTS points. The area 3 grade contributes approx. 21% to the final master's grade (25/120 ECTS).

1	Module name	**22610, 22615, 22620, 22625 - External Module**	**25 ECTS** **20 ECTS** **15 ECTS** **10 ECTS**
2	Courses/lectures	5 months placement (22610) 4 months placement (22615) 3 months placement (22620) 2 months placement (22625) at an external research institution or company	
3	Lecturers	Advisors of the Molecular Medicine program	
4	Module coordinator	Head of the audit committee	
5	Contents	The student can • do a laboratory course at a national or international research institute or • do a company/industry placement **All courses and placements must be in agreement with the study board before execution (learning agreement)**	
6	Learning objectives and skills	The students • can gain insight into international and industrial research environments • can acquire specialized knowledge and practical skills in a research field of their choice • independently organize the curriculum • cope with unfamiliar situations • can improve their language skills • present their work in written form	
7	Prerequisite	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 2nd and 3rd semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	26101, 26151, 26201, 26251 - Presentation, 20-30 min (pass/fail) 26102, 26152, 26202, 26252 - Practical work and protocol, 20-30 pages (graded)	
11	Grading procedure	100 % g~~G~~rade of the protocol	
12	Module frequency	Each semester	
13	Resit examination	~~Twice~~Three times	
14	Workload	22610: 750 h 22615: 600 h 22620: 450 h 22625: 300 h	
15	Module duration	1-2 terms	
16	Teaching and examination language	Depends on choice	
17	Recommended reading	Depends on choice	

1	Module name	**22630, 22635, 22640 - Laboratory Research Module**	**15 ECTS** **10 ECTS**
2	Courses/lectures	3 months laboratory course (22640) 2 months laboratory course (22630, 22635) at FAU	
3	Lecturers	Advisors of the Molecular Medicine program	
4	Module coordinator	Head of the audit committee	
5	Contents	The students work on a biomedical research project in a FAU laboratory of their choice. They independently study the related literature, plan, execute and document experiments and write a research protocol.	
6	Learning targets and skills	The students • acquire specialized knowledge in a research field of their choice • integrate into existing research groups • follow the rules of good scientific practice • plan, perform and document research experiments • utilize modern experimental techniques • present their work in written form	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	Elective compulsory module, 2nd and 3rd semester	
9	Module compatibility	M. Sc. Molecular Medicine	
10	Method of examination	26301, 26351, 26401 - Presentation, 20-30 min (pass/fail) 26302, 26352, 26402 - Practical work and protocol, 20-30 pages (graded)	
11	Grading procedure	100 % g~~G~~rade of the protocol	
12	Module frequency	Each semester	
13	Resit examination	~~Twice~~Three times	
14	Workload	300 h	
15	Module duration	1 term	
16	Teaching and examination language	Depends on choice	
17	Recommended reading	Depends on choice	

Area 4 – Master's thesis

Curricular Categories and Module Names	ECTS	Semester	
1999 - Master's thesis	**30**		**Area grade**
1998 - Master's thesis	25	4.	Graded
1997 - Master's colloquium	5	4.	Graded

The area grade is calculated as the average of the modules weighted by the modules' ECTS points. The area 4 grade contributes 25% to the final master's grade (30/120 ECTS).

1	Module name	**1998 - Master's Thesis**	**25 ECTS**
2	Courses/lectures	Research project	
3	Lecturers	Thesis advisors of the program	
4	Module coordinator	Head of the audit committee	
5	Contents	Independent investigation of an up-to-date research question from the field of molecular medicine: laboratory work, data analysis and written presentation. Generally, the students work on the research plans that they devised in the module "Project Development". A change of topic or laboratory must be approved by the study board.	
6	Learning targets and skills	The students • gain the ability to work on a current scientific topic for 5-6 months • apply the rules of good scientific practice to experimentation, documentation and data analysis • broaden their skills to plan, structure and work on complex problems • acquire subject specific knowledge in the chosen research field • plan and manage their project within the given time frame • develop concepts and approaches to solve a scientific problem • critically analyze and reflect on theories, concepts, terminology, limits and specific features of their chosen topic • choose appropriate scientific methods and apply them to new and interdisciplinary contents • present the data in a scientifically correct form • present, interpret and defend subject specific contents in a clear, audience-oriented form	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine The student must have passed the Advanced Lectures in Molecular Medicine 1 and 2 exams and have acquired 80 ECTS credit points from the curriculum prior to starting the master's project.	
8	Integration in curriculum	4th semester **Attention: close timing with the module "Master's colloquium"**	
9	Module compatibility	M. Sc. Molekulare Medizin	
10	Method of examination	1998 - Written Thesis Written elaboration in form of a scientific manuscript. It describes the scientific findings as well as the way leading to these findings. It contains justifications for decisions regarding chosen methods for the thesis and discarded alternatives. The student's own substantial contribution to the achieved results has to be evident. For more information, refer to No. 18.	
11	Grading procedure	100 % g~~G~~rade of the written thesis (arithmetic means of two expert reports)	
12	Module frequency	Each semester	
13	Resit examination	Once	

14	Workload	The thesis has to be prepared within 6 months
15	Module duration	1 Semester
16	Teaching and examination language	English
17	Recommended reading	Depends on thesis subject
18	Additional information	• The time limit for the preparation of the master's thesis is 6 months. The thesis advisors are asked to pay attention to ensure an adequate extent of the treated subject. • An extension up to one month is possible under well founded circumstances. • Normally, the thesis will be performed in the same lab as the module "Project Development" on the subject of the student's project proposal. A change of laboratory or subject must be approved by the study board. • It is recommended to invest five months into the experimental work and one month into writing the thesis. • The thesis must be written in English. It can only be written in German upon approval of the study board. It must adhere to the following formal requirements: font: Arial, size: 11 pt, spacing: 1,5x, legends beneath images or tables in 9 pt. • The thesis has the form of a scientific publication, including an index, a list of abbreviations, and the chapters 1. Abstracts in English and German, 2. Introduction, 3. Material and Methods, 4. Results, 5. Discussion, 6. Future Perspectives and 7. References. • The Abstract should not exceed 400 words (1 page). The whole thesis may not exceed 40.000 words and should generally be shorter than 100 pages. • The thesis must include a statement, that no other than the stated sources and aids were used. • The thesis must be submitted on time to the advisor(s) in two printed versions and an electronic version (PDF). The submission has to be documented on the official form issued by the study board. • Both advisors provide independent reports (1-2 pages) within one month after submission. The grading adheres to §20 Prüfungsordnung.

1	Module name	**1997 - Master's Colloquium**	**5 ECTS**
2	Courses/lectures	Colloquium	
3	Lecturers	Thesis advisors of the program	
4	Module coordinator	Head of the audit committee	
5	Contents	Presentation of the master's thesis in the framework of an all-day colloquium. The students present their work in a seminar, in which the scientific quality and the scientific independence of his/her achievements are evaluated. The thesis advisors evaluate the students' knowledge in the research subject and related subjects.	
6	Learning targets and skills	The students • present their data in a scientifically correct form • present, interpret and defend their research results in a clear, audience-oriented form • compare their results to published data • transfer subject-specific knowledge to other areas of biomedicine	
7	Prerequisites	Enrollment in the M. Sc. program of Molecular Medicine	
8	Integration in curriculum	4th semester	
9	Module compatibility	M. Sc. Molekulare Medizin	
10	Method of examination	1997 - Oral exam: presentation, discussion and open questions, approx. 15 min	
11	Grading procedure	~~G~~100 % grade of the oral exam	
12	Module frequency	Each semester summer term: colloquium in September winter term: presentation in presence of the examiners board	
13	Resit examination	Once	
14	Workload	1-2 days colloquium and preparation	
15	Module duration	1 Semester	
16	Teaching and examination language	English	
17	Recommended reading		