EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Module Handbook

Cellular and Molecular Neuroscience
Master of Science

Academic Year 2022-23

Faculty of Science and Medical Faculty
Graduate School of Cellular and Molecular Neuroscience

Content

1. Qualification goals of the master course 'Cellular and Molecular Neuroscience'

This research oriented course of study aims at German and international students with a first academic degree (BSc) in biology, molecular biology, molecular medicine, biochemistry, genetics, biotechnology, or medical sciences or in another relevant field of natural or engineering sciences. The theoretical and practical education comprises topics of molecular biology of neurons and glial cells, with a focus on neural diseases, of neurophysiology and of systems neuroscience. Furthermore, state-of-the-art neuroscience methods are covered, including cell and molecular imaging techniques and transgenic animals. Moreover, an emphasis is set on scientific writing and communication skills. The overall goal of the course is to impart solid knowledge and competences to qualify students to independently plan and carry out neuroscientific experiments and to critically evaluate their findings in comparison with published data. The qualification goals in more detail:

- Our graduates have a sound standing in basic and clinically oriented neuroscience, extending from genetic, molecular, cellular, and physiological biology of neurons and glial cells to genetic and molecular basis of neurodegenerative diseases. Moreover, neurochemistry, developmental biology, and sensory systems neurosciences and their pathologies are covered.
- Graduates have a solid theoretical and – to some extend – hands-on expertise in a wide range of state-of-the-art neuroscientific methods, including histological, molecular biological, stem cell, and cell and molecular imaging techniques. Also, they are well grounded in neurophysiological recording techniques and in basic statistical skills allowing them to analyze and statistically evaluate data.
- They are capable of critically scrutinizing the suitability of specific experimental approaches for studying various neuroscientific questions (*can I answer my scientific questions with the method at hand?*). Also, they will be able to combine techniques in a meaningful way to also make rather complex scientific problems accessible.
- Graduates have required English language competency, at least equivalent to C1-level. They can present scientific findings of their research orally and in writing. Moreover, in discussions they are skilled to answer scientific questions in a proficient manner. At scientific meetings, they can communicate – in English – with experts in the field and contribute to discussions on current neuroscientific topics.
- During their studies and laboratory rotations, graduates have also gained general competencies such as time and conflict management, coping with stressful situations, as well as social skills and the capacity for teamwork. Furthermore, as members of an international course-of-study and by working in internationally composed research groups they also gain cross-cultural competence to some extent.

In conclusion, after successful graduation form the master course students are well prepared to engage, eventually, in a demanding doctoral research project and pursue a career in science.

2. Modules overview

Module Code	Module Title	Semester	Credits
CM-01	Molecular and Cellular Neuroscience	1st	9
CM-02	Systems Neuroscience	1st	5
CM-03	Neurophysiology	1st and 2nd	6
CM-04	Methods in Neuroscience	1st and 2nd	10
CM-05	Neurogenetics and Clinical Neuroscience	1st and 2nd	12
CM-06	Stem Cells and Neuroglia	2nd	5
CM-07	Introduction to Current Research Topics	1st and 2nd	3
CM-08	Electives	1st and 2nd	12
CM-09	Laboratory Rotations	3rd	28
CM-10	Master Thesis	4th	30
			Sum 120

3. Timeline of the master course

1. Semester Winter Semester	2. Semester Summer Semester
Block Course I	Block Course II
Course Work *(CM-01 to CM-07)*	Course Work *(CM-01 to CM-07)*
Study Weeks // Exam Period	Study Weeks // Exam Period

3. Semester Winter Semester	4. Semester Summer Semester
1st Lab Rotation	Masters Thesis
2nd Lab Rotation	

4. Semester / Courses / Credits

1. Semester // Winter Semester	Credits	
Functional Neuroanatomy *(1 week block)*	2	
Molecular and Cellular Biology of Neurons and Glia	3	
Neurochemistry and Neurotransmitters	3	
Developmental Neurobiology	3	
Genetic and Molecular Basis of Neural Diseases I	3	
Human Neurogenetics	3	
Neurophysiology	3	
Sensory Systems – The Auditory System	3	
Essential Statistics for Neuroscience	3	
Methods in Molecular Neurobiology	2	
Elective Course	3	
NeuroColloquium	0,5	**Σ 31,5**

2. Semester // Summer Semester	Credits	
Neurohistol. and Quantitative Neuromorphology *(1 week block)*	2	
Genetic and Molecular Basis of Neural Diseases II	3	
From Molecules to Circuits: The Retina as a Model System	3	
Microscopy and Cell Imaging Techniques	3	
Stem Cells and Regeneration	2	
Neuroglia	3	
Journal Club	3	
Retreat	2	
NeuroColloquium	0,5	
Elective Courses	9	**Σ 30,5**

3. Semester // Winter Semester	Credits	
Laboratory Rotations incl. Seminars	**28**	**Σ 28**

4. Semester // Summer Semester	Credits		
Masters Thesis	**30**	**Σ 30**	
			Σ 120

5. Modules and examinations

Module	Module Element // Course	Course Requirements	Exam Period		
			Midterm WS / SS	Ex. Per. Spring	Ex. Per. Summer
CM-01	Molecular and Cellular Biology of Neurons and Glia	written exam (3 h)		X	
	Neurochemistry and Neurotransmitters				
	Developmental Neurobiology				
CM-02	Functional Neuroanatomy	written exam (1.5 h)	X		
	Sensory Systems – The Auditory System	written exam (2 h)		X	
CM-03	Neurophysiology	written exam (2 h)		X	
	From Molecules to Circuits: Retina as a Model System	written exam (1.5 h)			X
CM-04	Neurohistology and Quantitative Neuromorphology	oral examination	X		
	Methods in Molecular Neurobiology	written exam (1.5 h)		X	
	Microscopy and Cell Imaging Techniques	written exam (1.5 h)			X
CM-05	Genetic and Molecular Basis of Neural Diseases – I	written exam (3 h)		X	
	Human Neurogenetics				
	Genetic and Molecular Basis of Neural Diseases – II	written exam (1.5 h)			X
CM-06	Stem Cells and Regeneration	written exam (3 h)			X
	Neuroglia				
CM-07	Retreat	oral presentation	X		

This examinations overview shows:

- all examinations in the first year of study (1st and 2nd semester),
- the modules / module elements that are concluded with an examination,
- the type and the duration of an examination,
- the time points of the examinations (midterm, spring or summer examination period),
- and the number of exams in a given exam period (*please note the colour coding*).

6. Modules and module elements / courses

Code	Module	Module Coordinator	Term	Module Elements	CPs	Σ CPs
CM-01	**Molecular and Cellular Neuroscience**	Volkmer	1st	• Molecular and Cellular Biology of Neurons and Glia • Neurochemistry and Neurotransmitters • Developmental Neurobiology	3 3 3	**9**
CM-02	**Systems Neuroscience**	Gummer Rüttiger	1st	• Functional Neuroanatomy • Sensory Systems – The Auditory System	2 3	**5**
CM-03	**Neurophysiology**	Schwarz	1st + 2nd	• Neurophysiology • From Molecules to Circuits: Retina as a Model System	3 3	**6**
CM-04	**Methods in Neuroscience**	Jucker	1st + 2nd	• Neurohistology and Quantitative Neuromorphology • Methods in Molecular Neurobiology • Microscopy and Cell Imaging Techniques • Essential Statistics for Neuroscience	2 2 3 3	**10**
CM-05	**Neurogenetics and Clinical Neuroscience**	Jucker	1st + 2nd	• Genetic and Molecular Basis of Neural Diseases – I • Genetic and Molecular Basis of Neural Diseases – II • Human Neurogenetics • Journal Club	3 3 3 3	**12**
CM-06	**Stem Cells and Neuroglia**	Neher	2nd	• Stem Cells and Regeneration • Neuroglia	2 3	**5**
CM-07	**Introduction to Current Research**	Himmelbach	1st + 2nd	• NeuroColloquium • Retreat	1 2	**3**
CM-08	**Electives**	Himmelbach	1st + 2nd	• Elective Courses 1 – 4		**12**
CM-09	**Laboratory Rotations**	Himmelbach	3rd	• Laboratory Work + Lab Report • Seminar, Presentation of Lab Projects		**28**
CM-10	**Master Thesis**	Himmelbach	4th	• Laboratory Work + Thesis		**30**
					Sum	**120**

7. Descriptions of the individual modules (CM-01 to CM-10)

Module	Code: CM-01	ECTS Credit points
Molecular and Cellular Neuroscience		**9**

Module coordinator		
Prof. Dr. Hansjürgen **Volkmer**, Natural and Medical Sciences Institute		
Duration of module	**Cycle**	**Language of instruction**
1 Semester	Annually	English

Module elements

Course title	SWS	Course type	Semester*
Molecular and Cellular Biology of Neurons and Glia	2	Lecture	WS
Neurochemistry and Neurotransmitters	2	Lecture	WS
Developmental Neurobiology	2	Lecture + Seminar	WS

* WS = winter semester, SS = summer semester

Module content

This module provides comprehensive basic and advanced knowledge of the molecular and cellular biology of neurons and glia. On different levels, students are guided from the classification of neurons and glia, the cellular properties towards neural molecular biology. The module deals with aspects of cell structure, cell-cell interaction and communication, signalling, neurochemistry of neurotransmitters. Selected experiments exemplify problems of the experimental methodology. The different topics will be discussed in the context of the functionality, development and pathological alterations of the nervous system.

Qualification goals / learning targets

Successful completion of this module enables students to understand nervous system function and dysfunction at the molecular level and allows for the integration of molecular aspects of neuroscience into a functional view. Recent publications can be comprehended, both with regard to content and at the methodological level. Overall, the module provides broad knowledge and competences in molecular and cellular neuroscience and, thus is a prerequisite to deal with and integrate novel findings in the field. Furthermore, this module will lay the basis for the more advanced topics in the summer term.

Teaching methods

The majority of the module will be taught in lecture-style with regular, interposed tutorials. Students are expected to review topics after class by using their class notes and the hand-outs provided. Additional readings will be recommended and are generally available in the Graduate School's library. For the tutorials, short assignments have to be prepared and presented in class.

The seminar requires students to deal with developmental neuroscience topics in more depth. Students present – in groups of two – seminal papers on selected topics that have been addressed in the accompanying lecture. The core findings and conclusions of the studies will be discussed in class.

Prerequisites for participation

Solid background in general molecular and cell biology and in genetics.

Usability of the module

Compulsory module in the 1st semester of the master program Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

For the seminar part of the Developmental Neurobiology course, students are required to prepare and present a 20 minutes talk (pass/fail, not graded). In addition, the module will be examined by a 3 hours written exam in the spring exam period.

Workload assessment and credit points

Module elements	Hours*	CPs**
Molecular and Cellular Biology of Neurons and Glia	Co: 30h + Re: 30h + As: 10h + Ex: 20h = 90h	3
Neurochemistry and Neurotransmitters	Co: 30h + Re: 30h + As: 10h + Ex: 20h = 90h	3
Developmental Neurobiology	Co: 30h + Re: 30h + Se: 10h + Ex: 20h = 90h	3
	Total	**9**

* **Co**=Contact time in class, **Re**=review after class, **As**=assignments/homework, **Se**=preparation of seminar presentation, **Ex**=exam preparation/exam

** 30 hours workload = 1 ECTS credit point

Module	Code: CM-02	ECTS credit points
Systems Neuroscience		**5**

Module coordinator		
Prof. Dr. Anthony Gummer and Prof. Dr. Lukas Rüttiger, Tübingen Hearing Research Centre, UKT		
Duration of module	**Cycle**	**Language of instruction**
1 Semester	Annually	English

Module elements

Course title	SWS	Course type	Semester*
Functional Neuroanatomy	1 week block	Lecture + Practical + Tutorial	WS
Sensory Systems – Auditory System	2	Lecture	WS

* WS = winter semester

Module content

The aim of this module is to provide students - coming from diverse scientific backgrounds - with a common platform of theoretical and practical knowledge about the functional organisation of the main sensory and motor systems of the mammalian brain and its structural basis. The functional organisation of the mammalian brain is introduced on the microscopic and macroscopic levels from the spinal cord to the neocortex. Based on this general knowledge the auditory system will be covered as a model system for signal transduction at the sensory receptors to higher order processing and psychophysics. Principles of neural coding and information processing will be emphasized. The discussion of the intact system is complemented by excursions into the consequences of disease.

Qualification goals / learning targets

After successful completion of the module, students will be able to name and identify the major parts of the brain and their connectivity comprising the different sensory and motor systems pathways. They understand the function of different types of sensory receptor cells, receptor proteins, and their signal transduction cascades. Furthermore, students will be able to differentiate common and special features of neural information processing and coding of sensory information. Students will learn to explain molecular and cellular components underlying human and animal sensation. Moreover, students will have developed a basic understanding of dysfunction and diseases of a sensory system afflicting human patients.

Teaching methods

The functional neuroanatomy course is taught in a one-week block consisting of lectures in the morning and tutorials and supervised practical parts in the afternoon. Students will be provided with plastinated human brain sections and with histological slides of different kinds of brain tissue for macroscopic and microscopic inspection.

The Sensory Systems-Auditory System course is taught in lecture-style with interposed tutorials. Students are expected to review topics after class by using their class notes, the lecture slides, and recommended additional readings, such as textbooks and scientific journal articles. For the tutorials, students are expected to come armed with questions based on the lecture material. Moreover, as an aid for preparing their tutorial questions and for exercise, the lecturers will provide a list of questions after the lectures.

Prerequisites for participation

Basic notions of cell biology, physiology, and brain organisation are required.

Usability of the module

Compulsory module in the 1st semester of the master program Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

The final module grade will be compiled from two separate examinations. The written exam covering the functional neuroanatomy course will be held shortly after conclusion of the block course (midterm). The final sensory systems – auditory system examination consists of a written, graded exam covering the topics of the lectures taught in this module (75**%**) and regular weekly homeworks covering topics of that week's lecture (25%). Both exams are graded; the final exam grade will be weighted according to the credits allocated for the module elements (2:3).

Workload assessment and credit points

Module element	**Workload***	**CPs****
Functional Neuroanatomy	Co: 20h + Re: 20 + Ex: 20h = 60h	2
Sensory Systems – The Auditory System	Co: 30h + Re: 30h + As: 10h + Ex: 20h = 90h	3
	Total	**5**

* **Co**=Contact time in class + **Re**=review after class + **As**=assignments/homework + **Ex**=exam preparation and exam

** 30 hours workload = 1 ECTS credit point

Module	Code: CM-03	ECTS credit points
Neurophysiology		**6**

Module coordinator

Prof. Dr. Cornelius **Schwarz**, CIN,

Duration of module	Cycle	Language of instruction
2 Semesters	Annually	English

Module elements

Course title	SWS	Course type	Semester*
Neurophysiology	2	Lecture	WS
From Molecules to Circuits: The Retina as a Model System	2	Lecture	SS

* WS = winter semester, SS = summer semester

Module content

The brain's basic computational units are nerve cells and their synaptic contacts. Nerve cells use electrical and chemical signals to encode, compute and transfer information. The initial lecture course in this module focuses on the nature of electro-chemical signals, the mechanisms of their generation and transmission, and signal processing at the intra- and intercellular levels. The basic concepts, key experiments and methodological tools to study these issues are presented. Topics include basic electrical signalling mechanisms (resting-, action- and synaptic potentials), and other mechanisms of chemical and electrical signal generation, subcellular compartmentalization, and propagation (e.g. second messengers, calcium, etc.). Furthermore, electro- and opto-physiological techniques to investigate these signals will be discussed. These include intracellular recordings from soma and dendrites, extracellular recordings of spikes and local field potentials, stimulation techniques, and cellular imaging methods.

In the summer term, students will study more advanced, research-oriented neurophysiological topics. In contrast to other brain structures, activity of the retina can be observed – in a dish as an intact system – in response to physiologically relevant stimuli. Signal processing can be studied at the cellular and circuit level ranging from signal transduction in photoreceptors to signal processing in interneurons and retinal output neurons, the ganglion cells. Since much information is available on cell types, their morphology, function and connectivity, as well as the set of receptors and channels they express, the retina allows for investigation of complex questions in neuronal information processing. This course provides in-depth information on anatomy and function of the retina and introduces key topics in current retina research, such as diversity of neuron types, graded potentials, types of synapses, receptive fields, parallel signal pathways, visual feature-extracting circuits. It also addresses how the retina is used as a model system to understand more general neuroscientific questions.

Qualification goals / learning targets

Students will know the theoretical background of electrical signal generation, propagation, processing and integration in neurons. They will also understand the principles of transmission at chemical synapses. They will be able to explain how and when to use basic electro- and opto-physiological techniques to study signalling at the single cell and small neuronal network level. They will be able to interpret electrophysiological recording data from original publications.

Students will also be able to explain the structure and function of the retina at the cellular and circuit level and outline which circuits perform specialized functions in feature detection. They will be able to illustrate how advanced techniques such as gene transfer are used to manipulate retinal circuits. In addition, students will be able to evaluate the potential and limitations of the retina as a model system for sensory processing and neural circuit function.

After completion of this module, students can successfully apply their expertise to perform demanding laboratory or master thesis projects in synaptic and neural circuit physiology in brain systems including hippocampus, neocortex, amygdala, and retina. They are able to comprehend and critically evaluate current publications on neurophysiological topics.

Teaching methods

The module is taught in lecture-style with regularly interposed tutorials. Students are expected to review topics after class by using their class notes, hand-outs and lecture slides provided and recommended additional readings, such as textbooks and review articles. For the tutorials, short assignments have to be prepared.

Prerequisites for participation

Basic notions of cell biology, physiology and of brain organisation are needed.

Usability of the module

Compulsory module in the 1st year of the master program Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

The final module grade will be compiled from two separate examinations. The written exam covering the neurophysiology course will be in the spring exam-period, the written exam covering the retina course will take place in the summer exam-period. Both exams are graded; the final exam grade will be weighted according to the credits allocated for the module elements (3:3).

Workload assessment and credit points

Module element	Workload*	CPs**
Neurophysiology	Co: 30h + Re: 30h + As: 10h + Ex: 20h = 90h	3
From Molecules to Circuits: The Retina as a Model System	Co: 30h + Re: 30h + As: 10h + Ex: 20h = 90h	3
	Total	**6**

* **Co**=Contact time in class + **Re**=review after class + **As**=assignments/homework + **Ex**=exam preparation and exam

** 30 hours workload = 1 ECTS credit point

Module	Code: CM-04	ECTS Credit points
Methods in Neuroscience		**10**

Module coordinator
Prof. Dr. Mathias **Jucker**, HIH, Dept. Cellular Neurology

Duration of module	Cycle	Language of instruction
2 Semesters	Annually	English

Module elements

Course title	SWS	Course type	Semester*
Methods in Molecular Neurobiology	1	Lecture	WS
Neurohistology and Quantitative Neuromorphology	1 week block	Lecture + Practical	WS
Essential Statistics for Neuroscience	2	Lecture + Exercises	WS
Microscopy and Cell Imaging Techniques	2	Lecture	SS

* WS = winter semester, SS = summer semester

Module content

This module is composed of topics that aim at providing a coherent overview on major methods widely used in cellular and molecular neuroscience research.

It starts with an introduction to molecular biological methods, which are essential for the analysis of neural tissue and neuronal or glial cell cultures. The principles of different techniques are explained in the context of experiments employed to solve a neurobiological problem. The lecture covers state-of-the-art DNA analysis, mRNA-related techniques, protein-related techniques for structural and functional analysis of proteins and recombinant techniques. The course will also address genetically modified mouse models for studying neuronal functions at the cellular and molecular level, including transgenic over-expressing or knock-out animals and also cell type-specific and inducible mutants (Cre/lox site-specific recombination system).

The subsequent block course with hands-on elements introduces in routine histological techniques, immuno-histochemistry and *in situ* hybridization (to demonstrate the expression of proteins or mRNAs, respectively) that are employed to prepare brain tissue for light, fluorescence and electron microscopical examination. This course will also introduce unbiased stereological tools for quantitative morphological analysis.

In a third course in the summer term, in-depth microscopical and cell imaging techniques will be presented, from their physical and optical basis to their strength and pitfalls. The course covers light and fluorescence microscopy, the basic principles of high-resolution confocal and multi-photon microscopy as well as imaging techniques beyond the diffraction barrier (STED and TIRF microscopy). In addition, molecular imaging techniques will be presented (FRAP, FLIP, FRET, FLIM, calcium imaging) which serve to investigate and quantify cellular processes, protein-turnover or protein-protein interactions.

The application of statistical techniques is ubiquitous and compulsory in quantitative research and is required for properly reporting and publishing one's own results. The statistics course will provide students with basic tools needed to analyze quantitative molecular biological data. The topics include descriptive statistics, hypothesis testing as well as correlation and regression analysis.

Qualification goals / learning targets

After successful completion of the module, students will have a profound theoretical knowledge and basic practical skills in state-of-the-art neurohistological and microscopical techniques as well as genetic, molecular biological and transgenic animal techniques employed in modern neuroscience. In particular, students will be familiar with various microscopical techniques, their mode of operation and, most importantly, be able to critically evaluate their application in order to answer specific scientific questions, such as visualizing proteins or cellular

compartments or even cells *in vivo*. Students will also be able to interpret and draw information from microscopical images they produce or encounter in publications.

Students will have gained a level of expertise in wide range of molecular biology techniques that enables them to propose adequate methodological approaches to answer specific molecular neurobiological questions. Furthermore, they will be acquainted with widely used model organisms in neurobiology and their particular strengths and limitations for the analysis of neuronal functions such as, for example, mechanisms of behaviour or learning and memory.

The statistics course provides students with a toolkit for basic statistical data analysis and an understanding of important statistical concepts. At the end, students can apply these basic statistical approaches to their own data, they will be able to critically assess the statistical analysis used in publications and are aware of the most common pitfalls in the use of statistics.

In summary, the theoretical knowledge gained in this methods module together with the basic practical skills in histological, microscopical and molecular biological techniques will enable students to tackle demanding laboratory rotations in the second year of their studies. Moreover, this expertise will be essential for comprehension and interpretation of neurobiological experiments and findings published in the literature.

Teaching methods

The courses are taught in lecture-style with regular, interposed tutorials. Students are expected to review topics after class by using their class notes and the hand-outs and lecture slides provided. Additional readings will be recommended and are available in the Graduate School's library. For the tutorials, short assignments have to be prepared. The neurohistology course has an integrated practical part where students get first hands-on experience in various histological and microscopical techniques (taught in small groups).

The statistics course consists of lecture-style presentations and weekly problem sheets that cover statistical exercises related to the topics covered in class. Results from the problem sheets will be presented and reviewed in class. Statistical methods will also be trained by means of computer-based tutorials and by one straightforward project developed in small groups.

Prerequisites for participation

None

Usability of the module

Compulsory module in the first year of the master program Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

In the neurohistology course, students will be examined orally in groups (midterm exam held shortly after conclusion of the course, graded). The methods- and the microscopy lectures are concluded with a written exam (graded), each at the end of the respective term (spring and summer exam period). The final module grade will be calculated from the results of the oral and the two written examinations, weighted according to the credit points allocated (2:2:3). In order to 'pass' the statistics course, 60% of the homework assignments have to be achieved (pass/fail, not graded).

Workload assessment and credit points

Module element	Hours*	CPs**
Methods in Molecular Neurobiology	Co: 20h + Re: 20h + As: 10h + Ex: 10h = 60h	2
Neurohistology and Quantitative Neuromorphology	Co: 30h + Re: 20h + Ex: 10h = 60h	2
Essential Statistics for Neuroscience	Co: 30h + Re: 20h + As: 40h = 90h	3
Microscopy and Cell Imaging Techniques	Co: 30h + Re: 30h + As: 10h + Ex: 20h = 90h	3
	Total	**10**

Co=Contact time in class, **Re**=review after class, **As**=assignments/homework, **Se**=preparation of seminar presentation, **Ex**=exam preparation/exam
** 30 hours workload = 1 ECTS credit point

Module	Code: CM-05	ECTS Credit points
Neurogenetics and Clinical Neuroscience		**12**

Module coordinator

Prof. Dr. Mathias **Jucker**, Hertie-Inst. Clinical Brain Res., Dept. Cellular Neurology

Duration of module	Cycle	Language of instruction
2 Semesters	Annually	English

Module elements

Course title	SWS	Course type	Semester*
Genetic and Molecular Basis of Neural Diseases I	2	Lecture	WS
Human Neurogenetics	2	Lecture	WS
Genetic and Molecular Basis of Neural Diseases II	2	Lecture	SS
Journal Club	2	Seminar	SS

* WS = winter semester, SS = summer semester

Module content

This central module aims at understanding the molecular basis and pathophysiology as well as the preclinical and clinical therapeutic targets of major neural diseases.

In the 1st part of the course on neural diseases, neurodegenerative diseases with aging as the major risk factor, such as Alzheimer's disease, Parkinson's disease, and Frontotemporal dementia are discussed. In most of these diseases, whether they manifest as dementias or movement disorders, misfolding and/or aggregation of specific proteins occur. Although it is not proven that protein aggregations are always the cause for the disease, the focus of this lecture will be on learning how these aggregations develop, how they spread throughout the nervous system, how they relate to the disease pathomechanisms, and why the aging brain is such a dominant risk factor.

In the 2nd part of the course on neural diseases, the molecular pathophysiology of neural diseases in which neurodegeneration is believed to be a secondary event, such as cerebrovascular diseases, brain cancer, or demyelinating diseases such a multiple sclerosis is discussed. The course also covers neurodegenerative disease of sensory organs and the peculiar features of mitochondriopathies. Finally, as examples of neural diseases with disruption of the neural communications rather than neurodegeneration, schizophrenia and autism are discussed.

Many aspects of neural diseases are based on the discovery of genetic mutations causing rare Mendelian variants of the respective disorders. The course on human neurogenetics provides the basic principles of inheritance, molecular genetics and genomics, with special reference to neural traits and disease. Genetic variability and gene-environment interaction in the context of penetrance and expressivity, as well as applied aspects such as pedigree analysis, risk calculations, linkage analysis, association studies, and genetic analytics are discussed.

For the journal club, students will be provided with a reading list of most recent publications from the field of cellular and molecular neuroscience and state-of-the-art methods,. The lecturer will briefly introduce the papers and justify their selection for the journal club. Students will sign up for one specific paper and will present the essentials of the study in one of the following sessions. The journal club will acquaint the graduate students with key publications in their field of study and help them keep up with most recent findings in their field.

Qualification goals / learning targets

At the end of the course the students will be familiar with the molecular and cellular pathogenesis of major neural diseases. They will have an understanding of tauopathies, synucleinopathies, amyloidosis, and triplet repeat disorders and can formulate hypotheses why aging is a risk factor for these diseases. The students will be able to explain the molecular and pathological commonalities of the diseases and can contrast neurodegeneration

and neural dysfunction. Based on the molecular and cellular pathomechanisms for each disease the students will be able to justify potential future therapeutic targets.

Furthermore, students will know the basic principles of inheritance, their molecular components and mechanisms relevant for the understanding of the genetic basis of neural and in particular neurodegenerative diseases. They can analyze the designs of genetic studies and explain basic analytical technologies in human genetics, such as SNP-chip assays and next generation sequencing. With this knowledge students will be able to judge and criticize diagnostic and predictive genetic testing and reflect the rational for genetics-based treatment strategies.

The journal club will improve the students' skills of debating current research topics in their field of interest and to critically evaluate the findings published in recent articles: are the results of the study valid, how useful are the results and do the results lead to new research or to new applications. Furthermore, the adequacy of the research design, the controls used and the statistics employed are criticized.

After completion of this module, students will have solid competencies to perform demanding rotations or master thesis projects in laboratories pursuing clinically oriented research questions, including neurodegeneration and neurogenetics. Moreover, they are able to comprehend and critically evaluate current publications in these fields of research.

Teaching methods

The courses in this module are taught in lecture-style with interposed tutorials. Students are expected to review topics after class by using their class notes, the hand-outs provided and the textbooks and journal articles recommended by the lecturer. For the tutorials, short assignments have to be prepared and presented in class.

The journal club require students to deal with new, as yet unfamiliar neuroscience topics in more depth and to present talks on selected seminal papers. The core findings of the articles and the methods will be discussed.

Prerequisites for participation

Profound knowledge in cell and molecular biology of neurons and glial cells.

Usability of the module

Compulsory module in the 1st and 2nd semester of the master program Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

The module will be concluded with two written exams, the first one covers the two lectures of the winter term (exam in the spring period) while the second one covers the summer term lecture. Both exams are graded and contribute to the final module grade according to the ratio of the credit points assigned (6:3).

For the Journal Club, students will be provided with a reading list. Publications have to be read weekly and a short quiz needs to be completed before each session. Every student has to read two papers in detail and present the essentials of the study in the sessions. Students also have to prepare questions derived from the study, which will be discussed in class.

Workload assessment and credit points

Module element	Hours*	CPs**
Genetic and Molecular Basis of Neural Diseases I	Co: 30h + Re: 30h + As:10h + Ex: 20h = 90h	3
Human Neurogenetics	Co: 30h + Re: 30h + As:10h + Ex: 20h = 90h	3
Genetic and Molecular Basis of Neural Diseases II	Co: 30h + Re: 30h + As:10h + Ex: 20h = 90h	3
Journal Club	Co: 30h + Re: 10h + As: 50h = 90h	3
	Total	**12**

* **Co**=Contact time in class, **Re**=review after class, **As**=assignments/homework, **Se**=preparation of seminar presentation, **Ex**=exam preparation/exam

** 30 hours workload = 1 ECTS credit point

Module	Code: CM-06	ECTS Credit points
Stem Cells and Neuroglia		**5**

Module coordinator

Dr. Jonas **Neher**, DZNE / HIH, Experimental Neuroimmunology

Duration of module	Cycle	Language of instruction
1 Semester	Annually	English

Module elements

Course title	SWS	Course type	Semester*
Neuroglia	3	Lecture	SS
Stem Cells and Regeneration	2	Lecture	SS

* SS = summer semester

Module content

In the nervous system of vertebrates glial cells outnumber neurons 4-10 times. An understanding of their role in the development and function in the brain is therefore crucial knowledge for neuroscientists.-The lecture course on 'Neuroglia' focuses on the physiology and functions of glial cells in the nervous system and will cover the functions of glial cells derived from neuroectodermal precursors, namely astrocytes and myelinating cells. Topics will include for example the role of astrocytes in synaptic transmission, in regulation of blood flow, and in potassium homeostasis. Furthermore, modern imaging and electrophysiological techniques will be discussed which help investigate functions of astrocytes in vivo, e.g. during sensory activity or breathing. For myelinating cells, the course will highlight modern theories of myelination, the role of electrical activity during myelination, as well as functions of oligodendrocytes and Schwann cells beyond myelination. Another topic will be oligodendrocyte precursor cells, which form synapses with neurons (neuron-glia synapses) in grey and white matter of the brain and we speculate on the likely roles of neuron-glia synapses during development and myelination. The lecture will further introduce the innate immune system of the brain. In particular the microglial cells, the brain's macrophages, will be discusses with regards to their origin and their role in the healthy brain, including during brain development and synaptic monitoring. Also, their contribution to brain inflammation during neuropathological conditions and ageing will be highlighted, demonstrating their beneficial and detrimental responses to disturbances of brain homeostasis. Modern techniques for the *in vivo* observation and manipulation of microglia will be highlighted.

The second lecture of this module covers stem cells and their role in embryonic development and organ formation but also in the adult brain and during brain regeneration. Furthermore, this lecture series will discuss currently available methodology, including induced pluripotent stem cells (iPS cells) and their use for the generation of transgenic animals and also organoids. Finally, the lectures will highlight the potential clinical applications of stem cells, including stem cell-based therapies and stem cells for pharmacological and toxicological assays.

Qualification goals / learning targets

After the neuroglia lecture series, the students will be able to define the different glial cell types and their role in the healthy brain. Furthermore, they will be able to discuss how changes in glial function may effect neuronal health and contribute to neuropathology and relate this knowledge to current glia-directed therapeutic approaches. Students will also develop an understanding of state-of-the-art research methods for the investigation of glial cell function and how to apply these methods to further define the role of glia in brain health and disease.

The stem cells lecture will enable students to define the characteristics of this class of cells and the role these cells play in embryonic development and organ formation. Students will also be able to discuss the therapeutic opportunities that stem cells offer for brain regeneration and they will have a solid understanding of iPS cells and organoids as a research method and discuss their utility for clinical therapeutic approaches.

Teaching methods

The courses in this module are taught in lecture-style with interposed tutorials. Students are expected to review topics after class by using their class notes, hand-outs and the lecture slides provided. Also, the lecturer will recommend textbooks and journal articles. For the tutorials, short assignments have to be prepared and presented and discussed in class.

Prerequisites for participation

Basic knowledge in molecular biology, cell biology and physiology and related techniques.

Usability of the module

Compulsory module in the 2nd semester of the master program Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

The module will be concluded with a written exam in the summer examination period.

Workload assessment and credit points

Module element	Hours*	CPs*
Neuroglia	Co: 30h + Re: 30h + As: 10h + Ex: 20h = 90h	3
Stem Cells and Regeneration	Co: 15h + Re: 20h + As: 10h + Ex: 15h = 60h	2
	Total	**5**

- 30 hours workload = 1 ECTS credit point

Module	Code: CM-07	ECTS Credit points
Introduction to Current Research		**3**

Module coordinator

PD Dr. Marc **Himmelbach**, Graduate Training Centre of Neuroscience

Duration of module	Cycle	Language of instruction
2 Semesters	Annually	English

Module elements

Course title	Course type	Semester*
NeuroColloquium	Talks *(invited speakers)*	WS + SS
Weekend Seminar / Retreat *(changing topics)*	Student Seminar	SS

* WS = winter semester, SS = summer semester

Module content

The NeuroColloquium is a long-standing, fortnightly seminar series organized by the Tübingen neuroscience community. The seminar presents internationally renowned researchers from various fields of neuroscience. The talks have a review-like character providing an overview on state-of-the-art neuroscience topics, from genes to behaviour and new methodologies. Students will get the opportunity to choose speakers of their interest and meet with them before and after the talk.

Once a year, the master students of the two Graduate Schools will jointly attend a retreat where they present and discuss topics that are generally not part of their regular curricular course program. Past topics included: Sex Differences in the Brain, Neuropharmacology: From Basic Science to Marketable Drugs, Neuroprosthetics, Executive Functions, Philosophy of Mind, Ethics in Neuroscience, and Animals in Neuroscience Research. The seminar topics are usually proposed and cooperatively chosen by students and lecturer and change every year.

Qualification goals / learning targets

The intention of this module is to introduce students to a wide spectrum of current neuroscientific topics. The talks in the NeuroColloquium and the retreat complement one another to achieve this goal and provide insights in state-of-the-art neuroscience research questions and methodologies.

Particularly in NeuroColloquium students will get to know a wide range of neuroscience research topics and methods and makes them 'look beyond their own noses'. Of the 8 speakers visiting per semester, 2 speakers will be selected, invited and hosted by students of the Graduate Schools. By doing so, students actively participate in organizing a seminar series and will thereby gain organizational skills and social competence.

After successful completion of the retreat, students will have achieved skills that are required for scientific work in general, including literature search and preparation and presentation of a seminar talk on an unfamiliar topic. In addition to discussing and reflecting scientific topics, these retreats are also meant as social events where students from the three master programs meet with scientists and lecturers in a beautiful setting and a relaxed ambiance to get to know each other and to potentially initiate local co-operations.

Teaching methods

The retreat requires students to deal with new, as yet unfamiliar neuroscience topics in depth. The students present talks on general neuroscience topics. The core findings and conclusions will be discussed after the talk.

The NeuroColloquium is a bi-weekly seminar series with invited speakers.

Prerequisites for participation

None.

Usability of the module

Compulsory module in the 1st and 2nd semester of the master program Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

For the NeuroColloquium, regular attendance is required. Successful participation of the Retreat requires complete attendance and presentation of a 30 minutes talk on a selected topic. This module is not graded (pass/fail).

Workload assessment and credit points

Module element	Workload*	CPs**
NeuroColloquium (16 talks in total in WS and SS)	Co: 30h	1
Weekend Seminar / Retreat (2 days)	Co: 30h + Se: 30h = 60h	2
	Total	**3**

* **Co**=Contact time in class, **Re**=review after class, **As**=assignments/homework, **Se**=preparation of seminar presentation

** 30 hours workload = 1 ECTS credit point

Module	Code: CM-08	ECTS Credit points
Electives		**12**

Module coordinator
PD Dr. Marc **Himmelbach**, Graduate Training Centre of Neuroscience

Duration of module	Cycle	Language of instruction
2 Semester	Annually	English

Module elements

Course title	SWS	Course type	Semester*
Elective Courses	n.a.	n.a.	WS / SS

* WS = winter semester, SS = summer semester

Module content

Depending on the subjects of their previous training and/or their particular interests, students are free to choose courses from the masters programs Neural and Behavioural Sciences or Neural Information Processing or from any other masters program offered at Tübingen University. The electives may comprise advanced neuroscience or neuroscience methods courses, statistics or programming courses as well as courses on ethical, philosophical or related issues. Before the start of the term, students will be provided with a list of selected courses to choose from. Courses selected by a student have to be approved beforehand by the module coordinator.

Qualification goals / learning targets

The electives will impart students with specific knowledge and competencies in subject areas of their choice and may either deepen their knowledge in fields of their specialization or complement the training already provided with the compulsory curricular courses. By doing so, students can pursue their broad interest and can understand contexts and co-relations beyond the limits of their major discipline and, depending of the topics chosen, students will be imparted to discuss research topics interdisciplinary.

Teaching methods

Depends on the type of course selected.

Prerequisites for participation

Depends on the type of course selected. The course coordinator must approve the subjects of choice.

Usability of the module

Compulsory module in the 1st and 2nd semester of the master program Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

According to the specifications provided in the module description of the respective masters program.

Workload assessment and credit points

Module element	Hours*	CPs*
Elective Courses	360h	12
	Total	**12**

* 30 hours workload = 1 ECTS credit point

Module	Code: CM-09	ECTS Credit points
Laboratory Rotations		**28**

Module coordinator		
PD Dr. Marc **Himmelbach**, Graduate Training Centre of Neuroscience		
Duration of module	**Cycle**	**Language of instruction**
1 Semester / 2 x 10 Weeks	n.a.	English

Module elements

Course title	Course type	Semester*
1st Laboratory Rotation	Practical	WS
+ Presentation of Laboratory Projects	Student Seminar	
2nd Laboratory Rotation	Practical	WS
+ Presentation of Laboratory Projects	Student Seminar	

* WS = winter semester

Module content

Students are required to perform two laboratory rotations (10-weeks each, all day) where they work on small research projects in laboratories of their choice. In general, the assigned study is in line with currently on-going research in the respective laboratory and supervised at least by an advanced doctoral student or a postdoc. The lab projects have to be concluded with a written report (formatted like a scientific paper) and an oral presentation during a seminar at the end of the rotation, which provides a platform for the students to present their research projects.

The curriculum requires students to perform *two* experimental lab rotations, which should ideally be performed in *two* different research groups with distinct scientific questions and different methods.

Qualification goals / learning targets

During the lab rotations, students will acquire a wide range of practical skills in state-of-the-art methods and they get to know current scientific questions and research approaches. The skills trained during lab rotations include literature survey, planning of research project and design of experiments, documentation of data generated, critical evaluation and interpretation of results, compiling data for and writing of a report. In addition, social competences will be trained during collaboration with other members of the hosting research group. In the end, students have also learned to prepare and give an oral presentation on their research project.

After successful performance of the two laboratory rotations students will have gained theoretical and practical competencies to tackle a demanding master thesis project: they can identify a scientific question, they can implement adequate experiments and combine methods in a meaningful manner, they can critically analyse their data collected, reflect their findings and relate them to relevant findings of others, hypothesize about the potential meaning of their findings and generate genuine ideas for future experiments.

Teaching methods

Supervised practical training in the laboratory, including reading of research papers, writing of a report formatted like a scientific paper, oral presentation and discussion of the research findings. The student's progress is monitored through weekly meetings with her/his supervisor.

Prerequisites for participation

Successful completion of the winter and summer semester modules and project-specific knowledge gained in the first year of study.

Usability of the module

Compulsory module in the 3rd semester of the master program Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

The students' performance will be assessed and graded by the supervisor according to the following criteria: understanding of theoretical framework and literature overview (15%), practical work in the lab (30%), generation of own ideas (10%), oral presentation of the project and discussion in the seminar (15%), written lab report (30%). The evaluation will be done on a standardized form provided by the Graduate School.

Workload assessment and credit points

Module element	Workload *	CPs**
1st Laboratory rotation	Co: 9w = 360 h	12
Writing of report, preparing presentation, seminar	LR/Se: 7d = 56 h	2
2nd Laboratory rotation	Co: 9w = 360 h	12
Writing of report, preparing presentation, seminar	LR/Se: 7d = 56 h	2
	Total 832 h	**28**

* **Co**=contact time in laboratory, **LR**=writing of laboratory report, **Se**=preparation of seminar presentation, **w**=weeks, **d**=days, **h**=hours

** 30 hours workload = 1 ECTS credit point

Module	Code: CM-10	ECTS Credit points
Master Thesis		**30**

Module coordinator
PD Dr. Marc **Himmelbach**, Graduate Training Centre of Neuroscience

Duration of module	Cycle	Language of instruction
1 Semester / 6 Months	n.a.	English

Course title	Course type	Semester*
Experimental Master Thesis	Research Project	SS

*SS = summer semester

Module content

To complete their studies, students are required to prepare a master thesis in a laboratory of their choice. In general, the assigned project is in line with currently on-going research in the respective laboratory and supervised by the group leader or at least by an advanced postdoc. The experimental master thesis will require students to perform research more or less independently within the given period of time. The master's project will be concluded with a written thesis formatted like a scientific paper.

Qualification goals / learning targets

After successful completion of the master thesis, students have acquired profound practical skills in state-of-the-art methods applied in neuroscience. They are acquainted with current neuroscientific questions and recent publications in this particular field. They are trained in generating and analysing scientific data and writing a scientific report. In addition to scientific expertise, students will acquire soft skills, such as time and project management, working in international, interdisciplinary teams, English communication and writing skills, and rules of responsible conduct of research. Overall, with successful completion of the master thesis, students proof their scientific competence and demonstrate that they are well prepared to tackle demanding research projects such as, for example, a doctoral thesis (see also: 2nd paragraph of qualification goals of module **CM-09**).

Teaching methods

Supervised practical training in a laboratory, including reading of research papers, presentation of progress reports, and writing of a master thesis.

Prerequisites for participation

Successful completion of all theoretical and practical course requirements of the first 3 semesters (exams, lab rotations).

Usability of the module

Compulsory module in the 4th semester of the master course Cellular and Molecular Neuroscience.

Module requirements, exams and grading scheme

Students are required to submit – after 6 months of work – three copies of their thesis to the office of the Graduate School. At the student's request and upon hearing the supervisor, the examination board may grant an extension of the submission deadline for up to 4 weeks, at most. Two readers, one of which is the supervisor, will evaluate the thesis. The examination board will appoint the readers.

Workload assessment and credit points

Module element	Workload	CPs*
Master Thesis	23 w x 5 d x 8 h = 920 h	**30**

* 30 hours workload = 1 ECTS credit point (**w**=weeks, **d**=days, **h**=hours)