Faculty of Biology

Module description

Master of Science (M.Sc.) in the subject Neuroscience - Major Field
(Examination regulations version 2021)

universität freiburg

Table of Contents

Prolog

Version 2023-24

Brief description of the study program

Subject	Neuroscience
Degree	Master of Science (M.Sc.)
Study duration	120 ECTS / 4 semester
Type of study	Full-time
Type of degree program	Second degree with research thesis
University	Albert-Ludwigs-Universität Freiburg
Faculty	Fakultät für Biologie
Website	https://www.mscneuro.uni-freiburg.de/
Profile of the study program	This interdisciplinary, English-language Master's degree program in Neuroscience provides in-depth training in the field of Neuroscience; it is offered by the Faculty of Biology jointly with the Faculty of Engineering and the Faculty of Economics and Behavioral Sciences. It teaches the theoretical and experimental basics of Neuroscience as well as key methods of neuroscientific research, such as measurement techniques and quantitative methods for data analysis and modeling. The program enables students to build on this foundation by allowing them to specialize in one or more areas of the Neurosciences, such as Computational Neuroscience, Neural Circuits and Behavior or Neurotechnology. The teaching curriculum includes lectures, exercises, seminars, laboratory course and research projects. A workload of 120 ECTS credit points including a Master's thesis with research work within 6 months is required for graduation. Successful completion of the Master's degree program qualifies graduates for an academic career in higher education and at non-university research institutions, as well as for professions at medical institutions or in the biomedical industry.
Qualification goals of the degree program	*Professional qualification goals:* ■ Acquisition of knowledge in the theoretical and experimental foundations of neuroscience ■ Acquisition of central methods of neuroscientific research, such as measurement techniques and quantitative methods of data analysis and modelling ■ Acquisition of knowledge in an area of specialization in neuroscience, like for example Computational Neuroscience, Neural Circuits and Behavior or Neurotechnology ■ Ability to read, understand and summarize contemporary neuroscientific publications and literature ■ Ability to develop a neuroscientifc research project including a plan for its implementation ■ Experience with work flows in research projects at universities or research institutions

	Interdisciplinary qualification goals: ■ Ability to carry out independent scientific work ■ Acquisition of the ability to think abstractly and analytically and to work and communicate in a team ■ Ability to make decisions on complex matters ■ Preparation for the ability to take over management responsibility ■ Experience in international and intercultural areas ■ Social responsibility
Language	Classes and examinations in the Neuroscience Master degree program are generally conducted in English. Some of the elective classes and the associated examinations can also be held partly or entirely in German. As a rule, the Master Thesis has to be written in English. In justified cases and upon request, the student may be permitted to write the Master Thesis in German; in this case, the Master Thesis must include a summary in English.
Admission requirements	Admission to the M.Sc. in Neuroscience is open only to candidates who 1. have obtained a first degree with an average grade of 2.5 or better from a German institution of higher education in a Bachelor program focusing on natural science, mathematics, engineering, behavioral science or sports science or in an equivalent degree program of at least three years' duration at an institution of higher education in Germany or abroad which meets the requirements set out in paragraph (2), and 2. have knowledge of the English language which is at least the equivalent of level B2 of the Common European Framework of Reference for Languages. It is deemed the equivalent to an average grade of 2.5 or better in a first degree, if, in the program under sentence 1 no. 1, the applicant graduated with an average grade among the top 33 percent of the program's graduates of the previous three years.
Enrolment	only winter semester

Module im M.Sc. Neuroscience:

Modul	Art	SWS	ECTS	Semester	Studienleistung / Prüfungsleistung
Foundations of Neuroscience	V+Ü +S	10	12	1	SL PL: Klausur

Modul	Art	SWS	ECTS	Semester	Studienleistung / Prüfungsleistung
					PL: mündliche Präsentation
Methods in Neuroscience	V+Ü	14	18	1	SL PL: Klausur PL: schriftliche Ausarbeitung
Advanced Topics in Neuroscience	V+S	3	3	2	SL
Elective Subjects	variabel	variabel	27	2	SL PL: variabel PL: variabel
Research Project I	Projekt		15	3	PL: schriftliche Ausarbeitung PL: mündliche Präsentation
Research Project II	Projekt		15	3	PL: schriftliche Ausarbeitung PL: mündliche Präsentation
Master Thesis			30	4	PL: Masterarbeit PL: Präsentation der Masterarbeit

Abkürzungen: Art = Art der Lehrveranstaltung; SWS = vorgesehene Semesterwochenstundenzahl; Semester = empfohlenes Fachsemester; V = Vorlesung; Ü = Übung; S = Seminar; PL = Prüfungsleistung; SL = Studienleistung

Important notes regarding "Studienleistung" and "Prüfungsleistung":

Please note that the official German terms "Studienleistung/SL" and "Prüfungsleistung/PL" are translated as "course achievement" and "examination achievement", respectively, in this English version of the module handbook.

A "course achievement" can be the "regular participation" in a course. According to the "Prüfungsordnung für den Studiengang Master of Science (M.Sc.)" this means that students are not allowed to miss more than 15% of the teaching time (§13 (2)).

Name of module	Number of module
Foundations of Neuroscience	09LE03MO-NF-2021
Responsible	
Prof. Dr. Carsten Mehring	
Faculty	
Faculty of Biology	

ECTS-Points	12
Workload	360 h
Hours of week	10.0
Attendance	122 h
Independent study	238 h
Recommended semester	1
Duration	1
Compulsory/Elective (C/E)	Compulsory
Frequency	takes place each winter term

Compulsory requirement
None

Assigned Courses					
Name	Type	C/E	ECTS	HoW	Workload
From membrane to brain	lecture course	Compulsory	4.0	3.0	120 hours
Physiology, anatomy and behavior of neuronal systems	excercise course	Compulsory	5.0	5.0	150 hours
Selected Topics in Neuroscience	seminar	Compulsory	3.0	1.7	90 h

Qualification
The student ■ can explain the contents of the accompanying lectures and answer detailed questions regarding these. ■ can design and perform a simple electrophysiological experiment, including the physiological preparation and the usage of electronic and IT equipment needed, and report the results. ■ can prepare a simple neuroanatomical sample, perform basic staining procedures, and make drawings of the observed anatomical structures. ■ can perform basic neurophysiology experiments, recording extracellular spike activity from a grasshopper nerve. ■ can use the acquired knowledge, insights and skills to read, summarize and critically discuss scientific publications in the neurosciences. ■ can give a well-structured scientific presentation in English about a neuroscientific topic ■ improves their abilities to work in small teams. ■ improves their English competencies

Examination achievement
■ Written examination at the end of the module on the content of the lecture (weighted with 80% for the overall module grade); ■ Oral presentation of a neuroscience topic in the seminar (weighted with 20% for the overall module-grade)
Course achievement
■ Regular participation, conduction of all experiments of the course, oral presentation on the experiments and their results (Physiology course) ■ Regular participation, oral presentation of the experimental results and a matching theoretical topic (Anatomy course) ■ Regular participation, submission of experimental results, brief oral presentation on experimental design (Optogenetics & Behavior course) ■ Regular participation in the seminar
Recommendation
No animals are used in this module that fall under the authorization requirement of the Animal Welfare Act.
Usability
M.Sc. Neuroscience

↑

Name of module	Number of module
Foundations of Neuroscience	09LE03MO-NF-2021
course	
From membrane to brain	
Event type	Number
lecture course	09LE03V-OM-05-0001

ECTS-Points	4.0
Workload	120 hours
Attendance	46 hours
Independent study	75 hours
Hours of week	3.0
Recommended semester	1
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

The lecture provides an introduction to the structure and functional principles underlying brain function and neuroanatomical structures, organizational schemes, and processes in nerve cells and functional systems of the brain:

- structure and function of single neurons (dendrites, axons, synapses) and neuronal networks
- neuroanatomy of the mammalian brain
- basic electrical properties of biological membranes
- the generation and exchange of action potentials
- the interactions of neurons within and between neuronal networks
- physiology and molecular biology of synaptic plasticity and learning
- general principles underlying learning and behavior
- neurodevelopment: patterning, differentiation, axogenesis
- neural coding, decoding and neural computation
- auditory system, anatomy, networks and physiology
- visual system, anatomy, networks and physiology
- motor system, anatomy, networks and physiology
- somatosensory system, anatomy, networks and physiology
- prefrontal cortex and cognitive functions
- visual Illusions
- basal ganglia

Qualification

The students can

- explain the contents of this lecture and answer detailed questions regarding these.
- use this acquired knowledge and insights to read, understand and critically discuss scientific publications in the neurosciences.

Examination achievement

Written examination (2.5 hours) at the end of the module on the contents of the lecture

Course achievement
None
Literature

The Basics:

- Nicholls et al.: “From Neuron to Brain”, (4th ed), Ch 1,2,4-7,9

Neurodevelopment:

- Kandel et al: “Principles of Neural Science” (5th ed, 2012), Ch 52-55 or
- Squire et al.: “Fundamental Neural Science” (3rd ed, 2008), Ch 13-16 or
- Squire et al.: “Fundamental Neural Science” (4th ed, 2012), Ch 14-17 or
- Nicholls et al.: “From Neuron to Brain”, (4th ed), Ch 25

Hippocampus:

- Kandel et al: “Principles of Neural Science” (5th ed, 2012), Ch 15,21
- Bear et al. “Neuroscience: Exploring the Brain” (3rd ed, 2006) Ch. 7

Synaptic Plasticity:

- Kandel et al: “Principles of Neural Science” (5th ed,2012), Ch 55, 66

Auditory System:

- Kandel et al: “Principles of Neural Science” (5th ed,2012), Ch 21, 30, 31 or
- Bear et al. “Neuroscience: Exploring the Brain” (3rd ed, 2006) Ch. 11 or
- Squire et al.: “Fundamental Neural Science” (4th ed, 2012), Ch 22, 25 or
- Nicholls et al.: “From Neuron to Brain”, (4th ed), Ch 1, 22

Visual System:

- Kandel et al: “Principles of Neural Science” (5th ed,2012), Ch 25-29
- Squire et al.: “Fundamental Neural Science” (4th ed, 2012), Ch 26
- Heldmaier et al.: “Vergleichende Tierphysiologie” (2nd ed), Ch 18

Motors System:

- Kandel et al: “Principles of Neural Science” (5th ed, 2012), Ch 33-35,37,38

Somatosensory System:

- Bear et al. “Neuroscience: Exploring the Brain” (3rd ed, 2006) Ch. 12

Prefrontal Cortex:

- Kandel et al: “Principles of Neural Science” (5th ed,2012), Ch 67
- Squire et al.: “Fundamental Neural Science” (4th ed, 2012), Ch 50

Basal Ganglia:

- Kandel et al: “Principles of Neural Science” (5th ed, 2012), Ch 34 or
- Squire et al.: “”Fundamental Neural Science” (4th ed, 2012), Ch 30

Compulsory requirement
None

Teaching method
■ Lectures, Q&A and moderated discussions

↑

Name of module	Number of module
Foundations of Neuroscience	09LE03MO-NF-2021
course	
Physiology, anatomy and behavior of neuronal systems	
Event type	Number
excercise course	09LE03Ü-OM-05-0002

ECTS-Points	5.0
Workload	150 hours
Attendance	75 hours
Independent study	75 hours
Hours of week	5.0
Recommended semester	1
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

In this practical course, first practical experience in basic neurobiology will be gained in two of the following three areas:

- measuring physiological properties of neurons and neuronal networks in simple model systems, including handling measurement equipment, live tissue and incorporating key principles of experiment design and data analysis ("Physiology")
- comparative and functional neuroanatomy in rodents and humans on the basis of fixed tissue specimens and models, providing insight into basic mechanisms and cytoarchitecture of the mammalian brain. ("Anatomy")
- observing and quantifying animal behavior in conjunction with optogenetic modulation of ongoing neuronal activity and training in the basics of neurogenetic tools, behavioral experiments. ("Optogenetics & Behavior")

The students will be assigned to two out of the above three experiments on the basis of their priorities and available places. They will conduct one experiment in the first and one experiment in the second week of the course.

Qualification

The students can

- design and perform a simple electrophysiological experiment, including the physiological preparation and the usage of electronic and IT equipment needed, and report the results. The students can perform record extracellular spike activity from a grasshopper nerve.
- prepare a simple neuroanatomical sample, perform basic staining procedures, and make drawings of the observed anatomical structures.
- use this acquired knowledge, insights and skills to read, understand and critically discuss scientific publications in the experimental neurosciences.
- work in small teams.

Examination achievement

None

Course achievement
■ Regular participation in exercises according to § 13, para. 2 of the framework examination regulations Master of Science ■ Regular participation, conduction of all experiments of the course, oral presentation on the experiments and their results (Physiology course) ■ Regular participation, oral presentation of the experimental results and a matching theoretical topic (Anatomy course) ■ Regular participation, submission of experimental results, brief oral presentation on experimental design (Optogenetics & Behavior course)
Compulsory requirement
s. Modulebene
Teaching method
■ Lecture, experimental work in small groups ■ Media: Course scripts, Blackboard, Slide Presentations, Video Clips, anatomical and physiological preparations, electronic and optical measurement equipment, computers and software for data acquisition, analysis and visualization.

↑

Name of module	Number of module
Foundations of Neuroscience	09LE03MO-NF-2021
course	
Selected Topics in Neuroscience	
Event type	Number
seminar	09LE03S-NF-T3

ECTS-Points	3.0
Workload	90 h
Attendance	26 hours
Independent study	64 hours
Hours of week	1.7
Recommended semester	1
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
Student presentations of neuroscientific topics which extend the contents of the lectures “From Membrane to Brain”
Qualification
The students ■ extend their knowledge about the topics of the lecture “From membrane to brain” ■ can give a well-structured scientific presentation in English about a neuroscientific topic
Examination achievement
Oral presentation of a neuroscientific topic (30 min plus discussion)
Course achievement
Regular participation in seminar
Compulsory requirement
None
Teaching method
Student presentations and moderated discussions

↑

Name of module	Number of module
Methods in Neuroscience	09LE03MO-NM-2021
Responsible	
Prof. Dr. Stefan Rotter	
Faculty	
Faculty of Biology	

ECTS-Points	18
Workload	540 h
Hours of week	14.0
Attendance	185 h
Independent study	390 h
Recommended semester	1
Duration	1
Compulsory/Elective (C/E)	Compulsory
Frequency	takes place each winter term

Compulsory requirement
None

Assigned Courses					
Name	Type	C/E	ECTS	HoW	Workload
Scientific Programming in Python	excercise course	Compulsory	3.0	2.0	90 hours
Quantitative Methods and Statistics in Neuroscience - Lecture	lecture course	Compulsory	4.5	2.0	134 h
Quantitative Methods and Statistics in Neuroscience - Exercise	excercise course	Compulsory	4.5	7.0	137 h
Neurophysiology: Measurement and Analysis of Neuronal Activity	excercise course	Compulsory	6.0	4.0	180 h

Contents
Lectures will introduce important theoretical concepts and mathematical tools essential for model building and data analysis in biology and, in particular in neuroscience. Emphasis will be on deterministic and stochastic models, statistical analysis approaches in biology and network dynamics, and signal processing. These course contents are complemented by separate course units featuring a basic introduction to Python programming, and practical applications to neurophysiological data analysis using Matlab.
Qualification
The students have the competence to: ■ Convert a simple problem into a Python program ■ Implement simple programs for data analysis and data visualization ■ Explain the theory behind commonly used methods to analyze the various types of data obtained from biological systems (e.g. neuron spike trains, local field potentials).

- Apply theoretical concepts from linear systems theory, dynamical systems and stochastic processes to analyze and model biological data (e.g. neuronal spike trains) and infer mechanisms underlying the functioning of biological systems (e.g. the brain).
- Perform and interpret basic statistical analyses
- Discuss the limitations of experimental data and mathematical models and can derive countermeasures
- Explain how basic components of neurophysiological equipment work, their purpose and their limitations. They can design small circuits and use commercial electronic equipment typical for neurophysiological setups.
- Relate simple electronic circuits to neuronal properties and their dynamics
- Explain standard neurophysiological analysis tools and write own functions for the analysis of neurophysiological data in Matlab.

Examination achievement
PL 1 (Quantitative Methods and Statistics in Neuroscience): Written examination (2.5 hours) PL 2 (Neurophysiology: Measuring Neuronal Activity Dynamics and Plasticity in vitro): Individual written reports on the exercises and tasks in the electronics part (week 1) and on the data analysis part (week 2) by the due date. The grade will be calculated as the weighted sum of the report grades.
Course achievement
SL 1 (Scientific Programming in Python): Regular participation in discussion of exercises; Oral presentation of exercise solutions (approx. 20 min.) SL 2 (Neurophysiology: Measuring Neuronal Activity Dynamics and Plasticity in vitro): Regular participation in exercises (no absence permitted), successful completion of both parts of the course. SL 3 (Quantitative Methods and Statistics in Neuroscience): Participation in the discussion of the exercises and the successful presentation of solutions are obligatory course achievements.
Recommendation
No animals are used in this module that fall under the authorization requirement of the Animal Welfare Act.
Usability
M.Sc. Neuroscience

↑

Name of module	Number of module
Methods in Neuroscience	09LE03MO-NM-2021
course	
Scientific Programming in Python	
Event type	Number
excercise course	09LE03Ü-SP2-04_0001

ECTS-Points	3.0
Workload	90 hours
Attendance	30 h
Independent study	60 h
Hours of week	2.0
Recommended semester	1
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
This course equips students with the techniques to design their own scientific programs in Python, for example to analyze data or simulate a problem. The lectures cover basics of Python programming. ■ Variables, types and expressions ■ Loops, conditions and exceptions ■ Built-in functions and user designed functions ■ Numpy (numerical library for Python) ■ Plotting in Python, guidelines for good plotting practice
Qualification
The students have the competence to ■ Convert a simple problem into a Python program ■ Implement simple programs for data analysis ■ Implement simple programs for data visualization
Examination achievement
None
Course achievement
■ Regular participation in discussion of exercises according to § 13, para. 2 of the framework examination regulations Master of Science ■ Oral presentation of exercise solutions (approx. 20 min.)
Literature
The following literature is recommended for independent preparation and follow-up of the contents of the courses: http://www.python.org/ for some general information and an online tutorial on the programming language Python. Further documentation on the scientific libraries used in the course is also found online (http://scipy.org/).

Compulsory requirement
None
Teaching method
Lectures, students independently solve programming tasks on the computer

↑

Name of module	Number of module
Methods in Neuroscience	09LE03MO-NM-2021
course	
Quantitative Methods and Statistics in Neuroscience - Lecture	
Event type	Number
lecture course	09LE03V-NM-T2

ECTS-Points	4.5
Workload	134 h
Attendance	26 h
Independent study	108 h
Hours of week	2.0
Recommended semester	1
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
Lectures will introduce important theoretical concepts and mathematical tools essential for model building and data analysis in biology and, in particular in neuroscience. Emphasis will be on deterministic and stochastic models, statistical analysis approaches in biology and network dynamics, and signal processing. ■ Basic mathematics (numbers, vectors, calculus, linear algebra) ■ Simple dynamical systems ■ Signal processing and spectral analysis ■ Linear time invariant systems ■ Basic concepts in statistics
Qualification
Students ■ can explain the theory behind commonly used methods to analyze the various types of data obtained from biological systems (e.g. neuron spike trains, local field potentials) ■ are able to apply theoretical concepts from linear systems theory, dynamical systems and stochastic processes to analyze and model biological data (e.g. neuronal spike trains) and infer mechanisms underlying the functioning of biological systems (e.g. the brain) ■ can discuss the limitations of experimental data and mathematical models and can derive countermeasures ■ can perform and interpret basic statistical analyses
Examination achievement
Written examination (2.5 hours)
Course achievement
None
Compulsory requirement

Teaching method
Lectures

↑

Name of module	Number of module
Methods in Neuroscience	09LE03MO-NM-2021
course	
Quantitative Methods and Statistics in Neuroscience - Exercise	
Event type	Number
excercise course	09LE03Ü-NM-T2

ECTS-Points	4.5
Workload	137 h
Attendance	65 h
Independent study	72 h
Hours of week	7.0
Recommended semester	1
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
During the exercises, the content taught in the lectures is reviewed with the help of student tutors, and practical examples and applications are considered in terms of Python programming tasks.
Examination achievement
see lecture
Course achievement
Participation in the discussion of the exercises and the successful presentation of solutions are obligatory course achievements.
Compulsory requirement
None
Teaching method
Students independently solve programming tasks on the computer

↑

Name of module	Number of module
Methods in Neuroscience	09LE03MO-NM-2021
course	
Neurophysiology: Measurement and Analysis of Neuronal Activity	
Event type	Number
excercise course	09LE03Ü-NM-T3

ECTS-Points	6.0
Workload	180 h
Attendance	80 h
Independent study	100 h
Hours of week	4.0
Recommended semester	1
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

The course is intended to give a thorough introduction to the use of typical, electronic laboratory equipment and analysis techniques in neurobiological research, typical problems encountered and their solutions. The course consists of two parts

(1) Fundamental circuits and equipment

- Basic theory and application of analog circuits and analog to digital conversion in the context of
- neurophysiology
- Function and usage of oscilloscopes, amplifiers, frequency generators and FIR-filters
- Implementation of basic amplifier and RC-circuits
- Fundamentals of signal generation and recording in neuroscience
- Identification of functional units in research grade laboratory systems
- Junction potentials in ionic solutions

(2) Analysis of neuronal activity

- Fundamental concept of neurophysiological analysis techniques
- Introduction to Matlab
- Visualizing electrophysiological recordings
- Spike detection and segmentation
- Raster diagrams, spike rate estimation
- Peri-Stimulus time histograms (PSTH)
- Analysis of synaptic potentials (input resistance, time constants)
- Analysis of local field potentials (LTP), visualization of 3D data

Examination achievement

Individual written reports on the exercises and tasks in the electronics part (week 1) and on the data analysis part (week 2) by the due date. The grade will be calculated as the weighted sum of the report grades.

Course achievement

Regular participation in exercises (no absence permitted), successful completion of both parts of the course.

Compulsory requirement
none
Teaching method
Lectures, exercises, independent group work

↑

Name of module	Number of module
Advanced Topics in Neuroscience	09LE03MO-NA-2021
Responsible	
Prof. Dr. Carsten Mehring	
Faculty	
Faculty of Biology	

ECTS-Points	3.0
Workload	90 h
Hours of week	3.0
Recommended semester	2
Duration	1
Compulsory/Elective (C/E)	Compulsory
Frequency	takes place each summer term

Compulsory requirement
none

Assigned Courses					
Name	Type	C/E	ECTS	HoW	Workload
Advanced Topics in Neuroscience - Seminar	seminar	Compulsory	2.0	1.7	65 h
Advanced Topics in Neuroscience - Lecture	lecture course	Compulsory	1.0	1.2	25 h

Qualification
The student ■ can summarize several recent research findings in neuroscience including current neuroscientific research taking place at the University of Freiburg ■ has the competence to extract the important findings from a research publication and present them in a meaningful and well-structured scientific presentation in English
Examination achievement
none
Course achievement
■ Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science ■ Presentation of a neuroscience research topic (30 min plus discussion)
Recommendation
No animals are used in this module that fall under the authorization requirement of the Animal Welfare Act.

↑

Name of module	Number of module
Advanced Topics in Neuroscience	09LE03MO-NA-2021
course	
Advanced Topics in Neuroscience - Seminar	
Event type	Number
seminar	09LE03S-NA-T1

ECTS-Points	2.0
Workload	65 h
Attendance	15 h
Independent study	50 h
Hours of week	1.7
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
Students present recent research findings from the neuroscientific literature. The seminar takes place once a week.
Qualification
The student ■ has the competence to extract the important findings from a research publication and present them in a meaningful and well-structured scientific presentation in English
Examination achievement
none
Course achievement
■ Regular participation ■ Presentation of a neuroscience research topic (30 min plus discussion)
Compulsory requirement
none

↑

Name of module	Number of module
Advanced Topics in Neuroscience	09LE03MO-NA-2021
course	
Advanced Topics in Neuroscience - Lecture	
Event type	Number
lecture course	09LE03V-NA-T2

ECTS-Points	1.0
Workload	25 h
Attendance	25 h
Independent study	0 h
Hours of week	1.2
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
Neuroscientists from Freiburg present their own research. The lecture takes place once a week.
Qualification
Students ■ can summarize several recent research findings in neuroscience including current neuroscientific research taking place at the University of Freiburg
Examination achievement
none
Course achievement
■ Regular participation (since neuroscientists present their own research and not textbook knowledge, regular participation is necessary in order to achieve the qualification goal)
Compulsory requirement
none

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
Responsible	
Prof. Dr. Ilka Diester Prof. Dr. Andrew Straw	
Faculty	
Faculty of Biology	

ECTS-Points	27.0
Workload	750 h
Hours of week	
Recommended semester	2
Duration	
Compulsory/Elective (C/E)	Core elective
Frequency	takes place each summer term

Compulsory requirement

None

The table below contains more detailed information about the specific parts of the courses (some contain e.g. lecture and/or an excerice /seminar) and the Professors in charge.
Detailed information on the contentof each course can be found in the module desciption below.

Elective Module: Neural Circuits and Behavior

Course	ECTS	mandatory/ elective	SL/PL
9LE03-SP1-05 From Sensation to Behavior - Methods in Neuro-biology	9	m	PL
09LE03MO-WM-05 Cognitive Neuros-ciences	9	e	SL/PL
09LE03MO-WM-07 Developmental Neu-roscience	9	e	SL/PL
09LE03MO-WM-13 Neurobiology in Gene-tic Model Organism	9	e	SL/PL
09LE03MO-WM-30 Neurophysiology in vitro	9	e	SL/PL
09LE03MO-WM-31 Optogenetics for Neu-roscience	9	e	SL/PL

Assigned Courses					
Name	Type	C/E	ECTS	HoW	Workload
Methods in Neurobiology	excercise course	Compul-sory	9.0	11.0	270 Stun-den
Major Concepts in Cognitive Neurosciences	seminar		3.0	4.3	90 Stun-den
Methods in Cognitive Neurosciences	excercise course	Compul-sory	2.0	0.5	60 Stun-den
Selected Topics in Cognitive Neurosciences	seminar	Compul-sory	4.0	3.0	120 Stun-den
Development of the Nervous System and Emergence of Function	lecture course		1.0	1.0	30 hours
Methods in Developmental Neuroscience and Neural Circuit analysis	excercise course	Compul-sory	7.0	8.0	210 hours
Current Research Topics and Approaches in Circuit Development and Function	lecture course		1.0	1.0	30 hours
Visual circuits and visually guided behavior in Drosophila	lecture course		2.0	2.0	60 hours
Functional dissection of neural circuitries and behavior in Drosophila	excercise course	Compul-sory	6.0	6.5	180 hours
Neural circuits and behavior	seminar	Compul-sory	1.0	0.5	30 hours
Neurophysiology in vitro	excercise course	Compul-sory	9.0	9.0	270 Stun-den
Optogenetics for Neuroscience	lecture course		1.0	1.0	
Optophysiology	excercise course	Compul-sory	8.0	8.0	

Contents

For the “Elective Subjects” the student chooses one focus area from the following list:

- Neural Circuits and Behavior (coordinators: Prof. Diester, Prof. Straw)
- Computational Neuroscience (coordinator: Prof. Rotter)
- Neurotechnology (coordinator: Prof. Stieglitz)

Each focus area consists of mandatory and elective (i.e. optional) modules. The student must choose a sufficient number of elective modules such that mandatory and elective modules together are worth at least 27 ECTS. For further questions regarding the focus areas, please contact the coordinator of the focus area, the program coordinator Christina Kress-Metzler or Prof. Mehring.

Qualification

- The students have acquired in-depth knowledge in a research area of the neurosciences which each student choses individually from the following available areas:
- The students are able to critically evaluate and discuss important findings and scientific publications from the chosen area.
- The students can apply area specific experimental and/or theoretical research methods

Examination achievement
Each focus area has two graded assessments (“Prüfungsleistung”, PL). The type and scope of the assessments are defined in the module descriptions and are announced to the students at the beginning of each course. To do a PL, it may be required to successfully complete coursework in advance, e.g. you may need to successfully complete some exercises during the course before you can do an exam.
Course achievement
Specific criteria that need to be met to pass a “Studienleistung” are explained in the module description and announced by the lecturer at the beginning of the term. Examples of such “Studienleistung” are a report, a presentation or a written/oral exam, all of which are not graded, i.e. they can only be “passed” or “failed”. Sometimes you will receive a grade for a “Studienleistung” but this grade is only for your information to give you further feedback on your performance.
Examination weight
Each focus area has two graded assessments (“Prüfungsleistung”, PL). All other modules will not be graded but may contain ungraded assessments (“Studienleistungen”, SLs). The overall grade of the module “Elective Subjects” will be calculated as the weighted sum of both PLs as follows: overall grade = w1*grade PL1 + w2*grade PL2 w1 = ECTS PL1/(ECTS PL1 + ECTS PL2) w2 = ECTS PL2/(ECTS PL1 + ECTS PL2)
Recommendation
Please note: ■ Several modules are taught not only to MSc Neuroscience students but at the same time to students from other degree programs (e.g. M.Sc. Biology, M.Sc. Computer Science, M.Sc. Applied Physics etc). The same module may have different assessments depending on the degree program of the student. For example, while a report may be an SL for M.Sc. Neuroscience students (and therefore can only be “passed” or “failed)” it may be a PL (and therefore be graded) for a student from the M.Sc. Computer Science. ■ A few of the elective modules take place during winter term (as indicated by ‘WS’ behind the module name). In this case the participation takes places during the 3rd semester while students carry out their research project. It is usually not a problem do take part in a teaching module in parallel to a research project, however, this should be agreed by the supervisor of the research project. Please also note that research projects can already be started before the 3rd semester, e.g. in summer. ■ Some focus areas and modules have limitations with regard to the number of participants. In the case of too many applicants for a focus area or a module, students will be selected according to a procedure outlined in the M.Sc. Neuroscience examination regulations. Students which unfortunately cannot be registered for their first choice will be given the opportunity to choose other elective modules with sufficient number of places.
Usability
M.Sc. Neuroscience

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Methods in Neurobiology	
Event type	Number
excercise course	09LE03Ü-SP1-05_0002

ECTS-Points	9.0
Workload	270 Stunden
Attendance	165 Stunden
Independent study	105 Stunden
Hours of week	11.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

Three different ‘hands on’ courses (one week each) provide students with the opportunity to perform small neuroscience research projects (courses 1-3: EMG (Diester/Coulon), ERG (Reiff/Haikala), Behavior (Straw). An additional 4th course (Leibold) introduces into the field of ‘simulation and data analysis’, including work on your datasets from 1-3. Each course will be accompanied by group discussions and interactive presentations of theoretical and practical aspects. Students write a lab report on one of the performed research projects and get individual feedback and training on ‘how to write a high-quality report’. Morning-presentations provided by course instructors must be attended as they are required for later experiments.

Qualification

Students
- can design, perform and document experiments in different fields of neuroscience research, from early visual processing (ERG) to navigation behaviour in different insect species, from EEG & EMG recordings in humans to the control of muscles, movement and basic neuroprosthetic devices.
- are able to perform computer-controlled physiological recording experiments, quantitative measurements of movement and behaviour.
- are able to analyse and interpret recorded data.
- can relate their experiments to important theoretical concepts.
- can present, evaluate and discuss the results from own experiments and integrate them into the state of art in the research field.
- can explain both the usefulness and limitations of research on model organisms and humans.

Examination achievement

- evaluated lab report (50%) on one of the courses (1-4), topic will be assigned at the end of week 4.
- active participation and contribution (30%)
- Presentation / discussion of results (20%)

each to be passed (grade 4,0 or better)

Course achievement
■ Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science ■ Motivation & performance 30%, presentation / discussion of results 20%; written lab report in paper-style 50% on one of the topics (1,2,3 or 4; will be assigned at the end of week 4). Report in paper style, according to defined guidelines, including active feedback and rounds of improvement.
Literature
Course scripts for experimental work, preparatory literature like original articles and reviews will be provided in advance of as well as during the course.
Compulsory requirement
s. Modulebene
Teaching method
Experimental work by the students performed in small groups using electrophysiological, behavioral and computational techniques, supported by tutors. Practical demonstration of key techniques. Use of computer and Python software. Interactive presentations using blackboard and powerpoint / PDF, discussion as a group.

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Major Concepts in Cognitive Neurosciences	
Event type	Number
seminar	09LE03S-WM-05_0001

ECTS-Points	3.0
Workload	90 Stunden
Attendance	60 Stunden
Independent study	30 Stunden
Hours of week	4.3
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	
Language	english

Contents

Topics of the lectures given by various teachers are intentions, methods, and results of diverse fields of research that together contribute to our understanding of the relationship between cognition and the structure and physiology of brains.
Topics contain:

- Brain evolution
- Cognitive Psychology
- Neuroplasticity
- Perception
- Brain-machine interfaces
- Imaging methods
- Animal cognition
- Clinical neuroscience
- Neurophilosophy
- Brain Diseases
- Neurprostheses
- Sleep & Dreaming

Qualification

- Students can name major stages of human brain evolution.
- They can explain and differentiate several levels of neuroplasticity.
- They can name major benefits and limits of computational concepts for understanding cognitive functions.
- They identify similarities and differences between human and animal cognition.
- They can give examples of logical complications faced by the cognitive neurosciences.
- They can explain how neuroprotheses and brain-maschine interfaces work and effect the preception and cognition.

Examination achievement

none

Course achievement
Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science
Literature
Subject-specific literature will be recommended by lecturers during their presentations
Compulsory requirement
s. Modulebene
Teaching method
Lectures will be given as Power-Point presentation, including multimedia elements, backed by slide handouts. Intermitting discussions will be encouraged and coached.

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Methods in Cognitive Neurosciences	
Event type	Number
excercise course	09LE03Ü-WM-05_0002

ECTS-Points	2.0
Workload	60 Stunden
Attendance	8 Stunden
Independent study	52 Stunden
Hours of week	0.5
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

- demonstration of key methods in the cognitive neurosciences
- participation in experiments as subjects.

Qualification

The students can:
- identify major components and regions of human brain anatomy.
- explain EEG recordings, name the necessary equipment for it, and assess its fields of application.
- explain the principles of an MRI measurement and identify reasonable fields of application.
- plan and conduct experiments in teams, respect competencies of others and contribute their own skills constructively.
- explain how psychoacoustic tests for spatial auditory perception work.
- explain how animal navigation experiments work.

Examination achievement

M.Sc. Neuroscience students (if PL has been chosen): Two written lab reports (2 x 25% of the final grade)
The module is only passed if all parts have been passed.

Course achievement

- Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science
- Two written lab reports (2 x 25% of the final grade) - the module is only passed if all parts have been passed.
- writing a lab report each about the experimental procedures done or seen.

Literature

Course-specific literature will be recommended by the lab supervisior(s) during lab introduction or courses

Compulsory requirement

s. Modulebene

Teaching method
Students will be given hands-on experience of key-methods used in the cognitive neurosciences.

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Selected Topics in Cognitive Neurosciences	
Event type	Number
seminar	09LE03S-WM-05_0003

ECTS-Points	4.0
Workload	120 Stunden
Attendance	45 Stunden
Independent study	75 Stunden
Hours of week	3.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

- Two seminar blocks will be held for students to learn and discuss original papers about the cognitive neurosciences in general and about brain and language specifically.
- The students will learn how to read and evaluate original research reports.
- They will understand how to structure and present complex issues of current research.
- They will participate in scientific discussions and learn how to deal with controversies

Qualification

Students present and discuss specific scientific terms and concepts, observing the fundamental distinction between data and their interpretation.

Examination achievement

M.Sc. Neuroscience students (if PL has been chosen): Two oral seminar presentations (2 x 25% of the final grade)
The module is only passed if all parts have been passed.

Course achievement

- Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science
- Two seminar presentations of data and concepts contained in original literature
- The module is only passed if all parts have been passed.

Literature

To be distribute during the preparatory session.

Compulsory requirement

s. Modulebene

Teaching method

Seminars will be given by each student as media-supported Power-Point presentations.

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Development of the Nervous System and Emergence of Function	
Event type	Number
lecture course	09LE03V-WM-07_0001

ECTS-Points	1.0
Workload	30 hours
Attendance	14 hours
Independent study	16 hours
Hours of week	1.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	
Language	english

Contents

The lecture series offers a comprehensive overview regarding key aspects of vertebrate brain development and the emergence of functional neural circuits.
Specifically, lectures cover the distinct phases of nervous system development, starting from neural induction during gastrulation to formation of spatially organized neuronal networks, ordered synaptic connectivity, and the establishment of complex sensory systems. This includes key molecular mechanisms (e.g. transcriptional regulation, signaling pathways) that critically contribute to brain development. Also, important techniques and methods for analysis of nervous system development and function will be discussed.

Topics of the lectures:
- Introduction to neural development
- Neural Induction
- Neurulation
- Anterioposterior Patterning and Regional Organizing Centers
- Dorsoventral Patterning in the Nervous System
- Neurogenesis
- Neural Stem Cells
- Neuronal Differentiation
- Neurons and Glia
- Neural Crest
- Development of the Peripheral Nervous System
- Axon Guidance: molecular and cellular mechanisms, emergence of topographic representations
- Neurotrophic Factors and Neuronal Cell Death
- Synaptogenesis and Remodeling
- Sensory Organ Development and early Sensory Processing
- Emergence of goal-directed behaviors in a developing organism

Qualification

The students can:
- explain the fundamental phases of CNS development from neural induction to the formation of functional neuronal circuits
- explain molecular mechanisms of neural development (transcriptional control, signaling mechanisms)

- derive the fundamental morphogenetic processes during neurulation based on the participating signaling centers and the specific cell behavior
- explain the organisation of the vertebrate brain and spinal cord based on the anterioposterior and dorso-ventral patterning mechanisms that establish this organisation
- explain the roles of transcription factors and signals during region specific neuronal differentiation
- argue how Delta-Notch signaling controls neurogenesis
- explain the roles of neural stem cells and their stem cell niches in neural development and regeneration
- develop how distinct molecular mechanisms contribute to formation of functional connections in axo-noge- sis and synaptogenesis
- explain the formation of functional neuronal circuits in the embryo for simple behavioral paradigms (e.g. goal-directed behaviors, from vision to action)
- explain important classical and modern techniques for the experimental analysis of the distinct phases of neural development

Examination achievement

M.Sc. Biology: none
M.Sc. Neuroscience (if PL for WM-07 has been chosen): Oral examination on the content of the WM-07 with a focus on the lecture (30 min; weight of final WM-07 grade: 60%).

Course achievement

none

Literature

For independent follow-up learning of the topics of lectures the following text books as well as scientific reviews provided on ILIAS are recommended:

- Sanes et al., Development of the Nervous System (2012, 3rd. Ed. chapt. 1-7)
- Price et. al. Building Brains (2011, chapt.1-12)
- M. Barresi & S.F. Gilbert: Developmental Biology (2020; 12th Ed.): Chapters 5 (pages 155-160 only), 13-16
- Kandel et al. Principles of Neural Sciences (2012, 5th Ed. Part VIII)

Compulsory requirement

see module level

Teaching method

- Lectures using PowerPoint or Keynote presentations
- Handouts of lecture slides as b&w prints and as color PDFs on ILIAS server. Up-to-date scientific reviews for each topic provided on ILIAS
- Development of schemes using chalk / board
- Discussion of concepts and open questions

Recommendation

Lecture materials will be made available on ILIAS

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Methods in Developmental Neuroscience and Neural Circuit analysis	
Event type	Number
excercise course	09LE03Ü-WM-07_0002

ECTS-Points	7.0
Workload	210 hours
Attendance	120 hours
Independent study	90 hours
Hours of week	8.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

The practical course covers both classical techniques in embryology as well as modern molecular genetics, signaling research, advanced microscopy, recording of neural activity, and analysis of behavior.

This includes:
- live imaging using transmitted light, epifluorescence, confocal microscopy, multi-photon microscopy
- analysis of genetic mutants
- transgenic animal model systems
- embryo culture
- gene expression analysis and immunohistology
- overexpression of genes using mRNA microinjection or conditional gene expression systems
- pharmacological manipulation of signaling pathways
- analysis of axonogenesis
- analysis of sensory organ development
- visualizing pathways of early information processing, from sensory organs to spinal motor circuits
- analysis of neural circuit function using optophysiology (Ca^{2+} imaging) and electrophysiology
- analysis and quantification of motor behavior

Qualification

The students are able to:
- operate advanced microscopical systems (transmitted light, epifluorescence, single- and multiphoton confocal microscopes) and acquire scientifically meaningful imaging data.
- apply labeling techniques using synthetic and genetically encoded fluorescent indicators for imaging structure and function in defined neuronal populations.
- accomplish microinjections at the one-cell stage of embryos.
- identify essential anatomical structures in the nervous system of the vertebrate embryo.
- use time lapse analysis to determine the time course of fundamental processes in neural development.
- apply gene expression analysis and immunohistology to investigate mechanisms of CNS development.
- evaluate and apply different genetic techniques for the manipulation of signaling pathways and transcriptional control.
- evaluate and apply pharmacological techniques to manipulate signaling pathways.
- record, analyze and interpret functional data from calcium imaging and electrophysiological recordings.

- record and quantify early spontaneous and sensory-evoked locomotor behavior.
- utilize open source software to analyze digital immunofluorescence image data.
- statistically evaluate data for significance.
- plan and conduct experiments in teams, respect competencies of others and contribute their own skills constructively.

Examination achievement

M.Sc. Biology: none
M.Sc. Neuroscience (if PL for WM-07 has been chosen): Submission of lab report (approx. 20-30 pages incl. images/figures; weight of final WM-07 grade: 40%)

Course achievement

- Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science
- preparation of scientific protocols of laboratory projects.
- oral presentation and discussion of experimental findings from one of the various experimental sections of the course.

Literature

For independent follow-up learning of the topics of the practicals the following text books as well as scientific reviews provided on ILIAS are recommended:

- Sanes et al., Development of the Nervous System (2012, 3rd. Ed. chapt. 1-7)
- Price et. al. Building Brains (2011, chapt. 1-12)
- M. Barresi & S.F. Gilbert: Developmental Biology (2020; 12th Ed.): Chapters 5 (pages 155-160 only), 13-16
- Kandel et al. Principles of Neural Sciences (2012, 5th Ed. Part VIII)

Compulsory requirement

see module level

Teaching method

Instructions for practical work by faculty. Students perform experiments independently in teams of two or small groups with support by teaching staff.

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Current Research Topics and Approaches in Circuit Development and Function	
Event type	Number
lecture course	09LE03V-WM-07_0003

ECTS-Points	1.0
Workload	30 hours
Attendance	14 hours
Independent study	16 hours
Hours of week	1.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	
Language	english

Contents
In this lecture series, faculty and active researchers of the department will introduce their research area and ongoing projects. They will discuss state-of-the-art research projects, provide the relevant background, point out open questions, and will explain the most important experimental strategies and approaches used. Each lecture is accompanied by a discussion session.
Qualification
The students are able to ■ identify areas of current research on the development of nervous systems and the emergence of functional neuronal circuits. ■ explain the experimental strategies that are used to address scientific questions in the field. ■ explain advantages and limitations of key experimental techniques. ■ identify open questions in research projects that should be addressed in the future. ■ identify weak points in the design of scientific projects and the interpretation of results. ■ participate in scientific discussions on developmental and circuit neuroscience research in English.
Examination achievement
none
Course achievement
none
Literature
■ Independent follow-up learning of the topics of lectures using the lecture materials, text books and current scientific reviews ■ Recent published reviews for each topic will be provided to the students on ILIAS
Compulsory requirement
see module level

Teaching method
■ Interactive lectures using PowerPoint or Keynote presentations, development of schemes using chalk / board. About 30% of the time is reserved for discussion of concepts, methods, future perspectives and challenges of the research and open questions with the audience. ■ Handouts of lecture slides on ILIAS. ■ Up-to-date scientific reviews for each topic provided on ILIAS.

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Visual circuits and visually guided behavior in Drosophila	
Event type	Number
lecture course	09LE03V-WM-13_0001

ECTS-Points	2.0
Workload	60 hours
Attendance	30 hours
Independent study	30 hours
Hours of week	2.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	
Language	english

Contents

Lectures provided by Väinö Haikala and Dierk Reiff cover a wide range of topics that guide candidate researchers into the field of modern neuroscience research in the genetic model organism *Drosophila melanogaster*. Students become acquainted with recent insights into the architecture and function of in particular visual neuronal circuits that guide behavior in the fly. State-of-the-art methods (in particular opto- and neurogenetics) are presented that enable researchers to pursue combined genetic, anatomical, functional (physiological), and behavioral approaches to dissect the function of neuronal circuits and their role in behavior. The lecture focuses on mechanisms, neurons, and neuronal circuitries underlying vision, visual information processing, and visually guided behavior. Additional subjects may be included to address hot topics in current *Drosophila*neuroscience research.

Attendance is absolutely required to understand and perform subsequent practical work (experiments)

Selection of topics:
- Visual system and vision in Drosophila, including a comparison with vertebrate vision.
- Neuronal underpinnings of color vision, motion vision, optic flow processing in flies.
- unctional neuroanatomy of the fly nervous system and visual system.
- Comparison of traditional and recent approaches to investigate circuitries and mechanisms underlying visually guided behavior in flies
- Cell type- and cell-specific perturbation of neuronal function with genetic tools
- Optogenetic, thermogenetic and further genetic methods.
- Genetic tools for the investigation of functional neuroanatomy
- Design of experiments for the establishment of a causal relationship between identified neurons, neuronal information processing and control of behavior.
- Quantitative analysis of behavior in wild type and mutant flies
- Statistics and data analysis

All sections will be presented and discussed at a ‚medium-to-advanced level'.

Qualification

The students can
- describe the basic concepts of how visual information is transduced and integrated in neuronal circuits.

- explain the basic neuronal mechanisms underlying vision in vertebrates and flies.
- explain the basic encoding of visual information by the nervous system and know how this information is used to guide behavior in flies.
- use genetic techniques for the identification of the function of genes and proteins in neurons.
- design neurogenetic experiments in flies to disclose basic rules of information processing.
- design complex behavioral experiments and use appropriate equipment and technology.
- make use of the great potential of recent opto- and neurogenetic methods for the functional dissection of neuronal circuits.
- explain the basic functional properties and working principle of the most prominent neuro- and optogenetic actuators of neural activity.

Examination achievement

none

Course achievement

- Attendance is absolutely required to understand and perform subsequent practical work (experiments)

Literature

The following literature is recommended for independent preparation and follow-up of the course contents:

- Principles of Neural Science (Kandel, Schwartz, Jessel), Chapter 1-3 (Brain, Nerve Cells, Genes & Behavior), Chapters on Vision (6th edition, chapter 22)
- Further Literature will be provided during the course.

Compulsory requirement

see module level

Teaching method

- Power-Point presentations
- Comprehensive video material
- Interactive Black Board
- Hand-Outs
- Open discussion rounds
- 'Flipped classroom'

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Functional dissection of neural circuitries and behavior in Drosophila	
Event type	Number
excercise course	09LE03Ü-WM-13_0002

ECTS-Points	6.0
Workload	180 hours
Attendance	97,5 hours
Independent study	82,5 hours
Hours of week	6.5
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

Description of current experiments (the precise subject can vary):

- 'Functional neuroanatomy': Students will learn to dissect *Drosophila* heads and to generate explants of the brain of the fly. Proteins with specific functions in neurons and networks are labeled by use of antibodies and immunohistochemical methods will be used to fluorescently label the detected proteins *in situ*.
- CRISPER/Cas9-genome edited flies and genetic methods for the precise targeting of selected cell types are used to enable the detection of multi-epitope tagged proteins in these cells. In the focus of these experiments are proteins with a key role in synaptic information transfer.
- High-resolution confocal image stacks of fluorescence-labeled brains will be analyzed using freely available software (Image-J / Fiji).
- Planning and execution of behavioral experiments / analysis of visually driven behavior (phototaxis, spectral preference, navigation…).
- Data analysis and presentation.
- Study of literature and discussion in groups; presentation of important concepts in the plenum.

General:

Based on facts and theory covered by the lecture, the course provides students with the opportunity to investigate and dissect neuronal circuitries, and to pursue hands-on behavioral experiments guided by instructors. Flies are used as genetically amenable model organisms to establish causal relationships between identified neurons, information processing and behavior.

- Combined genetic and functional anatomical studies are performed to disclose insights into the identity and properties of neurons and circuitries.
- Students learn to use information on functional neuronal anatomy to design experiments .
- Mutant animals are analyzed to demonstrate that certain genes and proteins are required for neuronal processing and animal behavior.
- The concept of 'mutant' and 'mutant and rescue' experiments is introduced and applied.
- Experimental strategies to demonstrate necessity and/or sufficiency of neurons and proteins is introduced and applied.
- Neuro- and optogenetic actuators (like Channelrhodopsin,…) are used to perturb sensory information processing or motor control in flies The function of genetically targeted populations of neurons is perturbed (modified, activated, or inactivated) by heat, light, or using other techniques. In parallel behavior of flies is analyzed.

- Discussion of theory, obtained data and experimental approach.
- Hands-on experience and insights into daily life in a '*Drosophila* neural circuits lab.
- Demonstration of state-of-the-art techniques and setups used in the laboratory to functionally analyze and dissect the role of neurons and circuitries in visual information processing and control of behavior (*in vivo* 2-photon calcium imaging with genetically encoded Ca-sensor proteins, behavioral studies)

Qualification

The students
- can explain the basic concepts of how the nervous system controls behavior.
- can use or develop neurogenetic strategies for experimental investigation.
- are able to design and perform combined genetic, anatomical and functional (physiological) experiments.
- are able to design and perform combined neuro- /optogenetic and behavioral experiments in flies.
- are able to quantify and statistically analyze experimental data and to design appropriate control experiments.
- are capable of discussing complex problems in groups, of developing goal-oriented strategies and of solving problems in teams.
- can plan and conduct experiments in teams, respect competencies of others and contribute their own skills constructively.

Examination achievement

M.Sc. Neuroscience (if PL has been chosen): Written graded report
M.Sc. Biology: None

Course achievement

- Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science
- Students are obligated to present (ppt) their experiments and results in a diligent way.
- Diligent record keeping (lab-book).
- Writing of a report, assessed by course instructor of oral examinaton

Literature

Literature will be provided about two weeks prior the official beginning of the module.

Compulsory requirement

s. Modulebene

Teaching method

- Hands on, this is a practical course!
- Small teams of 2-3 students will be assisted by expert course instructors . Close interactions between students, teams, and instructors characterize this course.
- Black board and round-table discussions are used to debate questions, ideas, problems and results.
- Power-Point presentations will be used if inevitable.
- Flipped classroom

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Neural circuits and behavior	
Event type	Number
seminar	09LE03S-WM-13_0003

ECTS-Points	1.0
Workload	30 hours
Attendance	7,5 hours
Independent study	22,5 hours
Hours of week	0.5
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
Each student will prepare and present a research article on *Drosophila* neuroscience to the members of the course and the instructors (in English, using Power-Point or comparable). Science and style of presentation will be discussed be the whole team.
Qualification
The students can: ■ analyze a research article written in English. ■ compile its content and present it in English to a small audience using PowerPoint. ■ perform a critical evaluation of published work and demonstrate that published articles and information are not sacrosanct. ■ discuss a scientific article and answer questions in front of an audience.
Examination achievement
M.Sc. Neuroscience: diligent presentation M.Sc. Biology: none
Course achievement
■ Each student will present (ppt) a recent research article in English. ■ Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science
Literature
Students can chose articles or articles will be provided.
Compulsory requirement
s. Modulebene

Teaching method
■ PowerPoint presentations including videos ■ Handouts and original research publications ■ Discussion of data and style of presentation

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Neurophysiology in vitro	
Event type	Number
excercise course	09LE03Ü-WM-30_0001

ECTS-Points	9.0
Workload	270 Stunden
Attendance	135 Stunden
Independent study	135 Stunden
Hours of week	9.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

The course covers electrophysiological and behavioral aspects of neuroscience. Electrophysiological recordings are performed in acute brain slices of the hippocampus and in cell cultures of cortical neurons to teach widely used methods by recording and analyzing the activity and properties of individual neurons and networks. Behavioral experiments are conducted with adult rats. The course is an intense exercise using advanced techniques of neurophysiological and behavioral research, emphasizing independent use of high-tech equipment and critical analysis and interpretation of own research data.

Specifically, participants will perform
- Intracellular recordings using the patch clamp technique,
- Extracellular recordings using microelectrode arrays,
- Measure fundamental properties of neurons and networks,
- Analyze the properties of synaptic potentials,
- Measure local field potentials in different tissue configurations,
- Visualize activity dynamics in brain slices,
- Assess synaptic plasticity in paired pulse facilitation and long-term potentiation paradigms. Observations of naïve and trained rat behavior.
- Modifications of control software to adapt to the performance of the animals.
- Analyses of the recorded behavioral data.

The results obtained will be presented in the style of a conference workshop among the participants.

Qualification

The students
- are able to prepare and document immunocytochemical stains of brain slices
- can name neuronal subtypes in the hippocampus, fiber tracts and their connectivity and explain their functions, respectively
- can record and analyze electrical activity in individual neurons and networks with tools used in current research.
- are able to assess the electrophysiological properties of individual neurons, synaptic properties and network dynamics with the corresponding experimental paradigms and techniques.
- can stimulate neurons and neural tissue for different paradigms

- are able to present in speech and writing the concepts, implementations and interpretation of electrophysiological experiments in scientific style using own data.
- are able to critically assess electrophysiological experiments.
- are able to connect neurobiological concepts and signal with methods for their quantitative analysis.
- can design and perform guided paw movement training of a rat. In particular, the student will know the elements of basic rat behavior, and how to tune naïve behavior to a controlled behavior.
  can modify algorithms in a standard scripting language to guide the paw movements with real-time sensory feedback.
- can use this acquired knowledge, insights and skills to read, understand and critically discuss scientific publications in the experimental neurosciences.

Examination achievement

none

Course achievement

- Preparation for the practical parts using the course script,
- Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science

Literature

The following literature is recommended for independent preparation and follow-up of the course contents:
- Johnston, Wu: Foundations of Cellular Neurophysiology, MIT Press, Chapt. 1-6, 14, 15
- Wishaw & Kolb: The laboratory rat.Oxford University press, Chapter 14-15.
- Course script, primary literature and academic reviews as provided at the beginning of the course

Compulsory requirement

s. Modulebene

Teaching method

The course will be taught in the form of
- Interactive presentations,
- Individual work on electrophysiological and behavioral setups
- group work
- lab visits to research laboratories,
- tutoring during practical sessions and data analysis
- seminar presentations
- colloquia

The following media will be used:
- scripts for practical sessions,
- electrophysiological research equipment,
- lab equipment for histology
- Powerpoint presentations,
- several software toolboxes for data analysis and visualization,
- data from neurophysiological recordings.

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Optogenetics for Neuroscience	
Event type	Number
lecture course	09LE03V-WM-31_0001

ECTS-Points	1.0
Attendance	15 Stunden
Independent study	15 Stunden
Hours of week	1.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	
Language	english

Contents
The lecture covers optogenetic aspects of neuroscience. Specifically, the following topics are addressed ■ translation, transcription, genetic constructs ■ Cloning strategies ■ Delivery of opsins ■ Cell type specificity and circuit targeting ■ Combined optogenetic stimulation, neural recordings and behavior ■ Putative clinical applications ■ Calcium imaging via Two-Photon microscopy ■ Opsin variants and Opsin development ■ Non-opsin tools ■ Two photon imaging combined with optogenetic stimulation ■ optogenetic applications
Qualification
The students ■ can understand and summarize the contents of the lectures and answer detailed questions regarding these ■ can use this acquired knowledge and insights to read, understand and critically discuss scientific publications in the neurosciences
Examination achievement
none
Course achievement
none
Literature
The following literature is recommended for independent preparation and follow-up of the course contents: ■ Optogenetics: A Roadmap. Springer Protocols, Springer. Volume 133, ISBN 978-1-4939-7415-3 ■ Course script, primary literature and academic reviews as provided at the beginning of the course

Compulsory requirement
s. Modulebene
Teaching method
The course will be taught in the form of ■ Interactive presentations The following media will be used: ■ PowerPoint presentations

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
course	
Optophysiology	
Event type	Number
excercise course	09LE03Ü-WM-31_0002

ECTS-Points	8.0
Attendance	120 Stunden
Independent study	120 Stunden
Hours of week	8.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents

The course covers cloning and histological aspects as well as electrophysiological and optogenetic aspects of neuroscience. Neuronal activity is assed in cell cultures of cortical neurons to teach 2-Photon Calcium imaging and analyzing the activity and properties of individual neurons and networks. Extracellular recordings with optogenetic stimulations are provided from adult rats, which will be analyzed. Histology is performed on brain slices from adult rats. The course is an intense exercise using advanced techniques of neurophysiological and optogenetic research, emphasizing independent use of high-tech equipment and critical analysis and interpretation of own research data.

Specifically, participants will perform
- Molecular cloning (restriction enzyme cloning and Gibson assembly)
- Transient transfection of mammalian cells in culture
- Histology
- Calcium imaging via Two-Photon microscopy
- Measure fundamental properties of neurons and networks,
- Conduct antibody staining and fluorescence microscopy to assess opsin expression,
- Visualize activity dynamics in neuronal cultures,
- Analyses of the recorded neural data.

The results obtained will be presented in the style of a conference workshop among the participants

Qualification

The students
- understand the basics behind molecular cloning, are aware of the various cloning techniques available to them and are able to perform restriction based cloning and Gibson assembly
- are able to prepare and document immunocytochemical stains of brain slices
- can name neuronal subtypes in the cortex, cortical layers, fiber tracts and their connectivity and explain their functions, respectively
- can record and analyze electrical activity in individual neurons and networks with tools used in current research
- are able to assess the electrophysiological properties of individual neurons, synaptic properties and network dynamics with the corresponding experimental paradigms and techniques
- can stimulate neurons and neural tissue for different paradigms

- are able to present in speech and writing the concepts, implementations and interpretation of electrophysiological experiments in scientific style using own data
- are able to critically assess electrophysiological experiments
- are able to connect neurobiological concepts and signal with methods for their quantitative analysis.
- can modify algorithms in a standard scripting language to analyze neural data

can use this acquired knowledge, insights and skills to read, understand and critically discuss scientific publications in the experimental neurosciences

Examination achievement

M.Sc. Neuroscience students (if PL has been chosen): The grade will be based on the protocol (3.000-3.500 words; 70%) and the presentation (approx. 30 min; 30% - final seminar).

Course achievement

- Preparation for the practical parts using the course script
- Regular participation according to § 13, para. 2 of the framework examination regulations Master of Science

Literature

The following literature is recommended for independent preparation and follow-up of the course contents:
- Optogenetics: A Roadmap. Springer Protocols, Springer. Volume 133, ISBN 978-1-4939-7415-3
- Course script, primary literature and academic reviews as provided at the beginning of the course

Compulsory requirement

s. Modulebene

Teaching method

The course will be taught in the form of
- Interactive presentations
- Individual work on imaging and histological setups
- individual work on molecular cloning and transient transfection
- group work
- lab visits to research laboratories
- tutoring during practical sessions and data analysis
- seminar presentations
- colloquia

The following media will be used:
- scripts for practical sessions
- electrophysiological research equipment
- lab equipment for histology
- PowerPoint presentations
- several software toolboxes for data analysis and visualization
- data from neurophysiological recordings

↑

Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
Responsible	
Prof. Dr. Stefan Rotter	
Faculty	
Faculty of Biology	

ECTS-Points	27.0
Workload	750 h
Hours of week	
Recommended semester	2
Duration	1
Compulsory/Elective (C/E)	Core elective
Frequency	takes place each summer term

Compulsory requirement

None

The table below contains more detailed information about the specific parts of the courses (some contain e.g. lecture and/or an excerice /seminar) and the Professors in charge.
Detailed information on the contentof each course can be found in the module desciption below.

Elective Module: Computional Neuroscience

Course	ECTS	mandatory/ elective	SL/PL
Quantitative Methods 2	9	m	PL/SL
Biological Learning, Control and Decision Making	9	m	PL/SL
Models of Neurons and Networks	9	m	PL/SL

Assigned Courses

Name	Type	C/E	ECTS	HoW	Workload
Models of Neurons and Networks	excercise course	Core elective	9.0	7.0	270 h
Biological Learning, Control and Decision Making	excercise course	Core elective	9.0	6.0	270 h
Quantitative Methods 2	excercise course	Core elective	9.0	5.0	270 h

Contents

For the “Elective Subjects” the student chooses one focus area from the following list:
- Neural Circuits and Behavior (coordinators: Prof. Diester, Prof. Straw)
- Computational Neuroscience (coordinator: Prof. Rotter)
- Neurotechnology (coordinator: Prof. Stieglitz)

Each focus area consists of mandatory and elective (i.e. optional) modules. The student must choose a sufficient number of elective modules such that mandatory and elective modules together are worth at least 27 ECTS. For further questions regarding the focus areas, please contact the coordinator of the focus area, the program coordinator Christina Kress-Metzler or Prof. Mehring.

Qualification

- The students have acquired in-depth knowledge in a research area of the neurosciences which each student choses individually from the following available areas
- The students are able to critically evaluate and discuss important findings and scientific publications from the chosen area.
- The students can apply area specific experimental and/or theoretical research methods

Examination achievement

Each focus area has two graded assessments (“Prüfungsleistung”, PL). The type and scope of the assessments are defined in the module descriptions and are announced to the students at the beginning of each course. To do a PL, it may be required to successfully complete coursework in advance, e.g. you may need to successfully complete some exercises during the course before you can do an exam.

Course achievement

Specific criteria that need to be met to pass a “Studienleistung” are explained in the module description and announced by the lecturer at the beginning of the term. Examples of such “Studienleistung” are a report, a presentation or a written/oral exam, all of which are not graded, i.e. they can only be “passed” or “failed”. Sometimes you will receive a grade for a “Studienleistung” but this grade is only for your information to give you further feedback on your performance.

Examination weight

Each focus area has two graded assessments (“Prüfungsleistung”, PL). All other modules will not be graded but may contain ungraded assessments (“Studienleistungen”, SLs). The overall grade of the module “Elective Subjects” will be calculated as the weighted sum of both PLs as follows: overall grade = w1*grade PL1 + w2*grade PL2
w1 = ECTS PL1/(ECTS PL1 + ECTS PL2)
w2 = ECTS PL2/(ECTS PL1 + ECTS PL2)

Recommendation

Please note:
- Several modules are taught not only to MSc Neuroscience students but at the same time to students from other degree programs (e.g. M.Sc. Biology, M.Sc. Computer Science, M.Sc. Applied Physics etc). The same module may have different assessments depending on the degree program of the student. For example, while a report may be an SL for M.Sc. Neuroscience students (and therefore can only be “passed” or “failed)” it may be a PL (and therefore be graded) for a student from the M.Sc. Computer Science.
- A few of the elective modules take place during winter term (as indicated by ‘WS’ behind the module name). In this case the participation takes places during the 3rd semester while students carry out their research project. It is usually not a problem do take part in a teaching module in parallel to a research project, however, this should be agreed by the supervisor of the research project. Please also note that research projects can already be started before the 3rd semester, e.g. in summer.
- Some focus areas and modules have limitations with regard to the number of participants. In the case of too many applicants for a focus area or a module, students will be selected according to a procedure outlined in the M.Sc. Neuroscience examination regulations. Students which unfortunately cannot be registered for their first choice will be given the opportunity to choose other elective modules with sufficient number of places.

Usability
M.Sc. Neuroscience

↑

Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
course	
Models of Neurons and Networks	
Event type	Number
excercise course	09LE03Ü-NE-2-T1.1_b

ECTS-Points	9.0
Workload	270 h
Attendance	100 h
Independent study	170 h
Hours of week	7.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Core elective

Contents

Building on prior knowledge in neurobiology and quantitative methods acquired during the entry level modules, the lecture series “Models of Neurons and Networks” covers important concepts and tools in computational neuroscience and their mathematical foundations.

- Basic probability and statistics
- Linear and nonlinear dynamical systems
- Phase plane methods
- Continuous stochastic processes and point processes
- Graphs and networks, random graphs as well as specific models of biological neurons and networks
- Hodgkin-Huxley theory of the action potential
- Stochastic theory of ionic channels
- Synaptic integration and spike generation
- Correlations in recurrent networks and populations
- Dynamics of spiking networks and population dynamics
- Primary visual cortex and processing of visual information
- Models of plasticity, growth and maturation

Qualification

The interactive course is comprised of classical lectures (PDF slides) and interactive formats (blackboard/whiteboard). Active participation by the students is essential.

The students acquire the competence to

- link biological phenomena arising in network neuroscience with mathematical models using theory;
- understand the fundamental tradeoff between biological detail and mathematical abstraction and evaluate its consequences;
- explain the steps necessary to develop and validate models of a biological neuron, or a biological neuronal network, or a more abstract model of behavior;
- appreciate and explain the gain in understanding biological mechanisms arising from the study of mathematical models of neuronal systems;
- critically discuss the limits of mathematical modeling, numerical methods and statistics in computational neuroscience.

The combination of lectures and complementary exercises and tutorials will

- enhance the learning of new concepts and help acquiring new methods;
- weekly homework assignments are designed to encourage independent work;
- pencil and paper problems are solved either alone, in cooperation with other students or with the help of the tutor;
- computer simulations of firing rate models or spiking neuron models are designed and implemented;
- model-based data analysis of simulated data is applied.

Examination achievement
Written exam (70 minutes duration)
Course achievement
Presentation of selected exercise solutions (approx. 15 min.)
Compulsory requirement
None
Recommended requirement
Basic knowledge in the biological foundations of and quantitative methods in neuroscience.
Teaching method
Interactive lecture, plenary discussion triggered by the lecturer, joint discussion of simple examples at the blackboard. Problem solving alone or in small groups. Programming using Python, NEST or NEST Desktop. Data analysis using Python and suitable Toolboxes. Group discussions with support by experienced tutors.

↑

Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
course	
Biological Learning, Control and Decision Making	
Event type	Number
excercise course	09LE03Ü-NE-2-T1.2_b

ECTS-Points	9.0
Workload	270 h
Attendance	78 h
Independent study	192 h
Hours of week	6.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Core elective

Contents

Building on prior knowledge in neuroscience and mathematical methods, this course covers the computational neuroscience and modeling of biological learning, control and decision making. Topics include:

- Biological movement control
- Sensorimotor learning and motor adaptation
- Reinforcement learning in neuroscience
- Bayesian models in action and perception
- Neural networks of learning and control
- Brain-machine interfaces to study learning and control

Several of the methods and models covered in this course are related to developments in artificial intelligence and machine learning and thus, connections between models of brain function and AI will be a topic of discussion in this course.

The course consists of interactive lectures and accompanying exercises.

Qualification

The students acquire the competence to

- summarize models of biological learning, control and decision making
- link mathematical models with biological phenomena arising in systems neuroscience, using theory and computer simulations
- explain the fundamental tradeoff between biological detail and mathematical abstraction and evaluate its consequences
- explain the steps necessary to develop and validate models of behaviour their underlying neural mechanisms
- explain the gain in understanding biological mechanisms arising from the study of mathematical models and critically discuss the limits of mathematical modeling
- implement, simulate and analyse models and methods of biological learning, control and decision making
- compare models of different levels of abstraction

Examination achievement
Written exam (70 minutes duration)
Course achievement
Presentation of selected exercise solutions (approx. 15 min.)
Compulsory requirement
None
Recommended requirement
■ Basic knowledge in the biological foundations of neuroscience ■ Basic knowledge of quantitative methods ■ Enjoying mathematical modelling ■ Quantitative Methods and Statistics course ■ Python programming ■ Scientific Programming in Python course
Teaching method
Lectures, exercises and discussion Presentation and discussion of exercise solutions

↑

Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
course	
Quantitative Methods 2	
Event type	Number
excercise course	09LE03Ü-NE-2-T1.3

ECTS-Points	9.0
Workload	270 h
Attendance	75 h
Independent study	195 h
Hours of week	5.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Core elective

Contents

- Examples of probability distributions
- PCA,SVD
- Tuning curves and likelihoods, probabilistic decoding, Cramer Rao bound and Fisher Information
- Model identification: Linear filters (Fourier theory) Generalized Linear Models
- Learning and Regression
- Perceptrons and Patterns
- Support Vector Machines and Kernel trick
- Shannon Information and independence

Qualification

The students can
- answer detailed questions about the lecture contents
- explain the mathematical foundations of the introduced analysis concepts
- apply the analysis concepts to simple neuroscience problems
- generalize the presented methods to new problem variants
- explain the limitations of the presented analysis methods
- implement the analysis concepts from the lecture in python.
- reproduce mathematical derivations and proofs shown in the lecture
- apply the analysis concepts to small data sets

Examination achievement

Written exam (70 minutes duration)

Course achievement

- Attendance of the lecture is voluntary, but highly recommended.
- Regular participation in exercises

Literature

- Spikes; Bialek, de Ruyter van Steveninck, Rieke, Garland
- Introduction to Theoretical Neurobiology I; Tuckwell
- Information Theory, Inference and Learning Algorithms; McKay
- Advanced Data Analysis in Neuroscience: Integrating Statistical and Computational Models; Durstewitz

■ Pattern Recognition & Machine Learning; Bishop
Compulsory requirement
None
Recommended requirement
Quantitative Methods, enjoying mathematics
Teaching method
■ Presentation of lecture notes ■ Solving problem sheets together ■ Discussion of homework in tutorials ■ Homework problems require both programming (Python) and mathematical analysis

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
Responsible	
Prof. Dr.-Ing. Thomas Stieglitz	
Faculty	
Faculty of Biology	

ECTS-Points	27.0
Workload	750 h
Hours of week	
Recommended semester	2
Duration	
Compulsory/Elective (C/E)	Core elective
Frequency	takes place each summer term

Compulsory requirement

None

The table below contains more detailed information about the specific parts of the courses (some contain e.g. lecture and/or an excerice /seminar) and the Professors in charge.
Detailed information on the contentof each course can be found in the module desciption below.

Elective Module: Neurotechnology

Course	ECTS	mandatory/ elective	SL/PL
Biomedical Microsy-stems	6	m	PL
Neuroprosthetics	3	m	PL
Biomedical Instrumen-tation I	3	m	SL
Machine Learning	6	e	SL
Numerical Optimal Control in Science and Engineering	6	e	SL
Fundamentals of Elec-trical Stimulation	3	e	SL
Signal Processing and Analysis in Brain Signals	3	e	SL
Biological Learning, Control and Decision Making	9	e	SL
Implant Manufacturing Technologies	3	e	SL
EEG in Neuroscience and Clinical Neurology	3	e	SL

Assigned Courses					
Name	Type	C/E	ECTS	HoW	Workload
Biomedical microsystems	lecture course	Core elective	6.0	2.0	180 hours
Biomedical microsystems	excercise course	Core elective		2.0	
Neuroprothetik / Neuroprosthetics - Seminar	seminar	Core elective	3.0	3.0	90 hours
Biomedizinische Messtechnik I / Biomedical Instrumentation I - Lecture	lecture course	Compulsory	3.0	2.0	90 hours
Biomedizinische Messtechnik I / Biomedical Instrumentation I - Exercises	excercise course	Compulsory		1.0	
Biological Learning, Control and Decision Making	excercise course	Core elective	9.0	6.0	270 h
Maschinelles Lernen / Machine Learning - Lecture	lecture course	Core elective	6.0	3.0	180 Stunden | hours
Maschinelles Lernen / Machine Learning - Exercises	excercise course	Core elective		1.0	
Numerical Optimal Control in Science and Engineering	lecture course	Core elective	6.0	6.0	180 hours
Grundlagen der Elektrostimulation / Fundamentals of electrical stimulation - Lecture	lecture course	Core elective	3.0	2.0	90 hours
Technologien der Implantatfertigung / Implant Manufacturing Technologies - Lecture			3.0		
Technologien der Implantatfertigung / Implant Manufacturing Technologies - Exercises					
Signalverarbeitung und Analyse von Gehirnsignalen / Signal processing and analysis in brain signals - Lecture	lecture course	Compulsory	3.0	2.0	90 hours
EEG in Neuroscience and Clinical Neurology	lecture course		3.0	2.0	

Contents
For the “Elective Subjects” the student chooses one focus area from the following list: ■ Neural Circuits and Behavior (coordinators: Prof. Diester, Prof. Straw) ■ Computational Neuroscience (coordinator: Prof. Rotter) ■ Neurotechnology (coordinator: Prof. Stieglitz) Each focus area consists of mandatory and elective (i.e. optional) modules. The student must choose a sufficient number of elective modules such that mandatory and elective modules together are worth at least 27 ECTS. For further questions regarding the focus areas, please contact the coordinator of the focus area, the program coordinator Christina Kress-Metzler or Prof. Mehring.

Qualification
■ The students have acquired in-depth knowledge in a research area of the neurosciences which each student choses individually from the following available areas. ■ The students are able to critically evaluate and discuss important findings and scientific publications from the chosen area. ■ The students can apply area specific experimental and/or theoretical research methods
Examination achievement
Each focus area has two graded assessments (“Prüfungsleistung”, PL). The type and scope of the assessments are defined in the module descriptions and are announced to the students at the beginning of each course. To do a PL, it may be required to successfully complete coursework in advance, e.g. you may need to successfully complete some exercises during the course before you can do an exam.
Course achievement
Specific criteria that need to be met to pass a “Studienleistung” are explained in the module description and announced by the lecturer at the beginning of the term. Examples of such “Studienleistung” are a report, a presentation or a written/oral exam, all of which are not graded, i.e. they can only be “passed” or “failed”. Sometimes you will receive a grade for a “Studienleistung” but this grade is only for your information to give you further feedback on your performance.
Examination weight
Each focus area has two graded assessments (“Prüfungsleistung”, PL). All other modules will not be graded but may contain ungraded assessments (“Studienleistungen”, SLs). The overall grade of the module “Elective Subjects” will be calculated as the weighted sum of both PLs as follows: overall grade = w1*grade PL1 + w2*grade PL2 w1 = ECTS PL1/(ECTS PL1 + ECTS PL2) w2 = ECTS PL2/(ECTS PL1 + ECTS PL2)
Recommendation
Please note: ■ Several modules are taught not only to MSc Neuroscience students but at the same time to students from other degree programs (e.g. M.Sc. Biology, M.Sc. Computer Science, M.Sc. Applied Physics etc). The same module may have different assessments depending on the degree program of the student. For example, while a report may be an SL for M.Sc. Neuroscience students (and therefore can only be “passed” or “failed)” it may be a PL (and therefore be graded) for a student from the M.Sc. Computer Science. ■ A few of the elective modules take place during winter term (as indicated by ‘WS’ behind the module name). In this case the participation takes places during the 3rd semester while students carry out their research project. It is usually not a problem do take part in a teaching module in parallel to a research project, however, this should be agreed by the supervisor of the research project. Please also note that research projects can already be started before the 3rd semester, e.g. in summer. ■ Some focus areas and modules have limitations with regard to the number of participants. In the case of too many applicants for a focus area or a module, students will be selected according to a procedure outlined in the M.Sc. Neuroscience examination regulations. Students which unfortunately cannot be registered for their first choice will be given the opportunity to choose other elective modules with sufficient number of places.
Usability
M.Sc. Neuroscience

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Biomedical microsystems	
Event type	Number
lecture course	11LE50V-7900
Organizer	
Department of Microsystems Engineering, Biomedical Microtechnology	

ECTS-Points	6.0
Workload	180 hours
Attendance	60
Independent study	120
Hours of week	2.0
Recommended semester	
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Core elective
Language	english

Contents
The course presents exemplary applications of microsystems in biomedical engineering, discusses challenges and illustrates solutions to meet the requirements of biocompatibility, biostability and reliability in clinical applications. In detail, the following topic will be covered: ■ Introduction to Biomedical Microdevices ■ Medical Devices: Legal Framework and Classification ■ Glaucoma Monitoring Implant ■ Neual Implants to Restore Vision ■ Neural Implants to Record from the Brain ■ Sensors in Cardiac Pacemakers ■ Imaging Pills ■ Spectroscopic Billirubin Measurement ■ Trends for Intelligent Endoprostheses ■ Stability and Functionality Implantable MEMS ■ Packaging and Housing Concepts ■ Data and Energy Transmission in (Micro-)Implants Finally, the content of the course and the learning targets will be summarized together with the students to facilitate the preparation of the examination.
Examination achievement
see module details
Course achievement
see module details

Literature
Actual copies of the slides will be delivered accompanying to the lectures. Literature: ■ G. A. Urban (ed.) BioMEMS. Dordrecht: Springer 2006.
Compulsory requirement
none

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Biomedical microsystems	
Event type	Number
excercise course	11LE50Ü-7900
Organizer	
Department of Microsystems Engineering, Biomedical Microtechnology	

ECTS-Points	
Hours of week	2.0
Recommended semester	
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Core elective
Language	english

Contents
Examination achievement
see module details
Course achievement
see module details
Compulsory requirement
none
Recommended requirement
none

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Neuroprothetik / Neuroprosthetics - Seminar	
Event type	Number
seminar	04LE50V-5318

ECTS-Points	3.0
Workload	90 hours
Attendance	39 hours
Independent study	51 hours
Hours of week	3.0
Recommended semester	
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Core elective
Language	english

Contents

Introductory lessons contain:
- Basic concepts of neuroscience
- Interfacing the nervous system
- Modelling approaches for CNS applications
- Neuroethical aspects

Student covered topics will contain:
- Cochlea Implant - Deafness
- Retina Implant - Blindness
- Deep Brain Stimulation - Parkinson‘s Disease
- Spinal Cord Stimulation - Chronic Pain Syndrome
- Vagal Nerve Stimulation - Epilepsy
- Functional Electrical Stimulation - Drop Foot Syndrome
- Human Machine Interfacing - BCI and BMI
- Foreign Body Reaction

Examination achievement

see module details

Course achievement

None

Literature

- Farina, D., Jensen, W., Akay, M., Eds. (2013). INTRODUCTION TO NEURAL ENGINEERING FOR MOTOR REHABILITATION, IEEE
- Dagnelie, G., Ed. (2011). Visual Prosthetics: Physiology, Bioengineering, Rehabilitation: Physiology, Bioengineering and Rehabilitation, Springer
- DiLorenzo, D. J. and J. D. Bronzino, Eds. (2008). Neuroengineering Boca Raton, CRC Press
- Akay, M. (2007). Handbook of Neural Engineering, IEEE Press, Wiley

- Dornhege, G., et al., Eds. (2007). Toward Brain-Computer Interfacing. Neural Information Processing Series. Cambridge, MA, MIT Press
- Horch, K. W. and G. S. Dhillon (2004). Neuroprosthetics - Theory and Practice. Singapore-London, World Scientific Publishing

Compulsory requirement
None
Recommended requirement
High level knowledge in mathematics and natural sciences

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Biomedizinische Messtechnik I / Biomedical Instrumentation I - Lecture	
Event type	Number
lecture course	11LE50V-5301
Organizer	
Department of Microsystems Engineering, Biomedical Microtechnology	

ECTS-Points	3.0
Workload	90 hours
Attendance	39 hours
Independent study	51 hours
Hours of week	2.0
Recommended semester	
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
The course introduces different aspects of the recording of bioelectrical signals starting with the nerve and including amplifier design. It presents the most important medical diagnosis methods in the field of bioelectrical signals. In detail, the following topics will be covered: ■ Origin of bioelectrical signals ■ Electrochemistry of electrodes ■ Acute and chronic applications of electrodes ■ Recording and amplification of bioelectrical signals ■ Interference and artefacts ■ Bioelectrical signals of peripheral nerves and the muscle ■ Electrical signals of the heart (ECG) ■ Cardiac pacemakers and implantable defibrillators ■ Technical safety of medical devices Finally, the content of the course and the learning targets will be summarized together with the students to facilitate the preparation of the examination.
Examination achievement
see module details
Course achievement
see module details
Literature
Actual copies of the slides will be delivered accompanying to the lectures. Literature: **German**

1. Schmidt, Robert F., Lang, Florian, Thews, Gerhard (Hrsg.): Physiologie des Menschen, 29. Auflage. Heidelberg: Springer Medizin Verlag, 2005

English
1. Bronzino, Joseph D. (Hrsg.): The Biomedical Engineering Handbook, Volume 1 (and 2), Second Edition. Boca Raton: CRC Press 2000 / Heidelberg: Springer-Verlag, 2000
2. Enderle, John, Blanchard, Susan, Bronzino, Joseph (Hrsg.): Introduction to Biomedical Engineering, Second Edition. Burlington, San Diego, London, Elsevier, 2005

Compulsory requirement
None
Recommended requirement
None

↑

Name of module	**Number of module**
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Biomedizinische Messtechnik I / Biomedical Instrumentation I - Exercises	
Event type	Number
excercise course	11LE50Ü-5301
Organizer	
Department of Microsystems Engineering, Biomedical Microtechnology	

ECTS-Points	
Hours of week	1.0
Recommended semester	
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
Examination achievement
see module details
Course achievement
see module details
Compulsory requirement

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Biological Learning, Control and Decision Making	
Event type	Number
excercise course	09LE03Ü-NE-2-T1.2_b

ECTS-Points	9.0
Workload	270 h
Attendance	78 h
Independent study	192 h
Hours of week	6.0
Recommended semester	2
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Core elective

Contents

Building on prior knowledge in neuroscience and mathematical methods, this course covers the computational neuroscience and modeling of biological learning, control and decision making. Topics include:

- Biological movement control
- Sensorimotor learning and motor adaptation
- Reinforcement learning in neuroscience
- Bayesian models in action and perception
- Neural networks of learning and control
- Brain-machine interfaces to study learning and control

Several of the methods and models covered in this course are related to developments in artificial intelligence and machine learning and thus, connections between models of brain function and AI will be a topic of discussion in this course.

The course consists of interactive lectures and accompanying exercises.

Qualification

The students acquire the competence to
- summarize models of biological learning, control and decision making
- link mathematical models with biological phenomena arising in systems neuroscience, using theory and computer simulations
- explain the fundamental tradeoff between biological detail and mathematical abstraction and evaluate its consequences
- explain the steps necessary to develop and validate models of behaviour their underlying neural mechanisms
- explain the gain in understanding biological mechanisms arising from the study of mathematical models and critically discuss the limits of mathematical modeling
- implement, simulate and analyse models and methods of biological learning, control and decision making
- compare models of different levels of abstraction

Examination achievement
Written exam (70 minutes duration)
Course achievement
Presentation of selected exercise solutions (approx. 15 min.)
Compulsory requirement
None
Recommended requirement
■ Basic knowledge in the biological foundations of neuroscience ■ Basic knowledge of quantitative methods ■ Enjoying mathematical modelling ■ Quantitative Methods and Statistics course ■ Python programming ■ Scientific Programming in Python course
Teaching method
Lectures, exercises and discussion Presentation and discussion of exercise solutions

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Maschinelles Lernen / Machine Learning - Lecture	
Event type	Number
lecture course	11LE13V-1153
Organizer	
Department of Computer Science, Professorship in Machine Learning	

ECTS-Points	6.0
Workload	180 Stunden | hours
Attendance	45 Stunden | hours
Independent study	120 Stunden | hours
Hours of week	3.0
Recommended semester	
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Core elective
Language	english

Contents

- Applications / typical problems dealt with by machine learning
- basic data analysis pipeline (from data recording to output shaping)
- software libraries
- linear methods (e.g. LDA, logistic regression, ICA, PCA, OLSR) for dimensionality reduction, classification, regression and blind source separation
- non-linear methods (e.g. support vector machines, kernel PCA, decision trees / random forests, neural networks) for classification and regression
- unsupervised clustering (e.g. k-means, DBSCAN)
- algorithm independent principles in machine learning (z.b. bias-variance trade-off, model complexity, regularization, validation strategies, interpretation of trained machine learning models, basic optimization approaches, feature selection, data visualization)

Examination achievement

Siehe Modulebene \|
See module level

Course achievement

Siehe Modulebene \|
See module level

Literature

Duda, Hart and Stork: Pattern Classification
Christopher Bishop: Pattern Recognition and Machine Learning
Hastie, Tibshirani and Friedman: The Elements of Statistical Learning
Mitchell: Machine Learning
Murphy: Machine Learning – a Probabilistic Perspective

Criminisi et. al: Decision Forests for Computer Vision and Medical Image Analysis
Schölkopf & Smola: Learning with Kernels
Goodfellow, Bengio and Courville: Deep Learning
Michael Nielsen: Neural Networks and Deep Learning

In addition, literature for every section of the course is announced during these sections.

Compulsory requirement

keine | none

Recommended requirement

We have to rely on a solid background in basic math, specifically linear algebra (an eigenvalue decomposition, matrix operations, covariance matrices etc. should be very familiar concepts), calculus and probability theory.

We use the Python programming language for most of our assigments. If you do not yet have Python experience, you must ramp up at least basic knowledge thereof.

We recommend basic knowledge of optimization and of the scikit-learn Python library.

Teaching method

For in-class lectures:

Despite the large lecture rooms, a teacher-centered style shall be enriched as much as possible by measures like:

- interactive question and answer rounds
- discussions in sub-groups, reporting to the large group
- cross-teaching
- problem-oriented teaching e.g. via data analysis competition
- repetition of important concepts in slightly altered contexts.

For virtual lectures:

- flipped classroom teaching with videos provided
- Q&A sessions to discuss the videos' content
- Cross-teaching via Ilias forum
- problem-oriented teaching e.g. via data analysis competition
- repetition of important concepts in slightly altered contexts.

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Maschinelles Lernen / Machine Learning - Exercises	
Event type	Number
excercise course	11LE13Ü-1153
Organizer	
Department of Computer Science, Professorship in Machine Learning	

ECTS-Points	
Attendance	15 Stunden | hours
Hours of week	1.0
Recommended semester	
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Core elective
Language	english

Contents
The exercises are intended to give students a better understanding of the most important techniques they learn during lectures. They are expected to implement some selected methods to gain experience in practical applications.
Examination achievement
Siehe Modulebene | See module level
Course achievement
Siehe Modulebene | See module level
Compulsory requirement
none
Recommended requirement
none

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Numerical Optimal Control in Science and Engineering	
Event type	Number
lecture course	11LE50V-5249
Organizer	
Department of Microsystems Engineering, Systems Control and Optimization	

ECTS-Points	6.0
Workload	180 hours
Attendance	78 hours
Independent study	102 hours
Hours of week	6.0
Recommended semester	
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Core elective
Language	english

Contents
■ Introduction: Dynamic Systems and Optimization ■ Rehearsal of Numerical Optimization ■ Rehearsal of Parameter Estimation ■ Discrete Time Optimal Control ■ Dynamic Programming ■ Continuous Time Optimal Control ■ Numerical Simulation Methods ■ Hamilton-Jacobi-Bellmann Equation ■ Pontryagin and the Indirect Approach ■ Direct Optimal Control ■ Differential lgebraic Equations ■ Periodic Optimal Control ■ Real-Time Optimization for Model Predictive Control
Examination achievement
see module details
Course achievement
see module details
Literature
1. Manuscript "Numerical Optimal Control" by M. Diehl and S. Gros 2. Biegler, L.T., Nonlinear Programming, SIAM, 2010
Compulsory requirement
None

Recommended requirement
Mathematics 1 and 2 for Engineers or basic Linear Algebra and Calculus courses. Numerical Optimization (NUMOPT), Modelling and System Identification (MSI), Systems and Control Bachelor or Master lectures.

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Grundlagen der Elektrostimulation / Fundamentals of electrical stimulation - Lecture	
Event type	Number
lecture course	11LE50V-5306

ECTS-Points	3.0
Workload	90 hours
Attendance	30 hours
Independent study	60 hours
Hours of week	2.0
Recommended semester	
Frequency	takes place each winter term
Compulsory/Elective (C/E)	Core elective
Language	english

Contents
The course introduces the medical and biological as well as the physicochemical and technical aspects of electrical stimulation. In detail, students get familiar with the following topics: Overview of the history of electrical stimulation Anatomy and physiology of nerve and muscle Description of nerve excitation Electrical fields and electrochemical processes at electrodes Electrode designs and applications Charakteristic parameters during technical excitation of nerves Methods for selective stimulation Effects of chronic electrical stimulation Limits of safe electrical stimulation Systems theory aspects of control of neural prostheses Simulation of nerve excitation Stimulator design Overview of stimulation parameters in clinical applicationsFinally, the content of the course and the learning targets will be summarized together with the students to facilitate the preparation of the examination.
Examination achievement
see module details
Course achievement
None
Literature
A script will be provided to accompany the lecture and will be updated regularly. Further reading material: ■ Horch, K.W., Dhillon, G.S. (Hrsg.): Neuroprosthetics – Theory and Practice. (Series on Bioengineering & Biomedical Engineering – Vol. 2) ■ River Edge: World Scientific Computing, 2004

Compulsory requirement
None
Recommended requirement
None

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
Technologien der Implantatfertigung / Implant Manufacturing Technologies - Lecture	
Event type	

ECTS-Points	3.0
Hours of week	
Recommended semester	
Frequency	
Compulsory/Elective (C/E)	

Contents
Examination achievement
Course achievement
Compulsory requirement

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
Technologien der Implantatfertigung / Implant Manufacturing Technologies - Exercises	
Event type	

ECTS-Points	
Hours of week	
Recommended semester	
Frequency	
Compulsory/Elective (C/E)	

Contents
Examination achievement
Course achievement
Compulsory requirement

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
Signalverarbeitung und Analyse von Gehirnsignalen / Signal processing and analysis in brain signals - Lecture	
Event type	Number
lecture course	11LE50V-5312
Organizer	
Department of Microsystems Engineering, Biomedical Microtechnology	

ECTS-Points	3.0
Workload	90 hours
Attendance	26 hours
Independent study	64 hours
Hours of week	2.0
Recommended semester	
Frequency	takes place each summer term
Compulsory/Elective (C/E)	Compulsory
Language	english

Contents
The course starts with an introduction to the basic principles of the measurement of neurophysiological signals mainly EEG and MEG. Despite a basic technical introduction of the measurement systems an overview about physiological and pathological patterns and rhythms in brain signal is given. Pattern recognition in the diagnostics of patients suffering from epilepsy is one core topic of the module. Long term recordings of EEG in epilepsy diagnostic create a high demand for automatic EEG analysis procedures. Three different types of events are at the moment in the focus for automatic detection strategies. a) Epileptic seizures, which are the core syndrome of the disease. Automatic detection may facilitate the review of long term recordings tremendously. b) Short high amplitude peaks in EEG and MEG called spikes contribute to the diagnoses of epilepsy and give information related to the localization of the seizure onset region in focal epilepsy. c) Oscillatory activity in the frequency range between 80 Hz and 600 Hz gives according to recent result probably more specific information about the seizure origin area than spikes. Signal processing and pattern recognition strategies are presented and how they can be applied to the patterns of interest in epilepsy diagnostic. In detail following strategies will be presented: a) Heuristics b) Template matching c) Wavelet transformation d) Hilbert transformation e) Background and target modelling f) Artificial neural networks A second focus of the module is related to the localization of generators of neuronal activity based on EEG and MEG measurements. The introduction starts with the presentation of the Maxwell equations and the common simplifications as they are applied in EEG and MEG source localization. Localization includes two basic components, the for-

ward simulation and an inverse parameter estimation procedure. Concepts of the following forward models representing the physical properties of the head are presented: a) Spherical model b) Boundary element model c) Finite element model Main types of focal and distributed inverse models will form the contents of the inverse part of the source localization procedure. Exemplary application examples will show the complete processing chain from measurements and image acquisition to localization results.
Examination achievement
see module details
Course achievement
None
Compulsory requirement
None
Recommended requirement
None

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
course	
EEG in Neuroscience and Clinical Neurology	
Event type	Number
lecture course	04LE59S-NeurEF014-11

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	
Frequency	takes place each summer term
Compulsory/Elective (C/E)	
Language	english

Contents
The origin of the electromagnetic signal of the brain, quantitative analysis of EEG signal, technical basics and practical training high-density EEG, montages, artifacts, normal variants, sleep and visual rating of EEG, pathologies such as regional slowing, artifacts, epileptic activity, special features of the EEG in childhood, video-EEG monitoring in presurgical diagnostics.
Qualification
Participants will learn to independently rate EEG and take the first steps in the quantitative analysis of EEG. The course is primarily designed for students of the Master of Neuroscience, doctoral students, and residents in Neurology.
Examination achievement
Oral exam at the end of the course.
Course achievement
100% active participation.
Literature
To be distributed during the first seminar.
Compulsory requirement
Teaching method
Seminars will be given by media-supported powerpoint-presentations, one session with hand-on pratical training in EEG acquisition and evaluation of evoked potential.

↑

Name of module	Number of module
Research Project I	09LE03MO-NR-1-2021
Responsible	
PD Dr. Philippe Coulon	
Faculty	
Faculty of Biology	

ECTS-Points	15.0
Workload	450 h
Hours of week	
Recommended semester	3
Duration	1
Compulsory/Elective (C/E)	Compulsory
Frequency	each term

Compulsory requirement
Foundations of Neuroscience, Methods in Neuroscience
Recommended requirement
Elective Subjects. Research Projects in some groups may require certain background knowledge and techniques taught in the Elective Subjects.

Assigned Courses					
Name	Type	C/E	ECTS	HoW	Workload

Qualification
The student ■ can carry out a neuroscientific Research Project under the supervision of an experienced researcher ■ can write a scientific report about their Research Poject ■ can give a scientific oral presentation about their Research Project ■ can explain the neuroscientific topic of their Research Project

Examination achievement
PL1: Written report (80%) PL2: Oral presentation (20%) **Written report** The written report should have the form of a short scientific paper, typically including the sections Introduction, Methods, Results and Discussion followed by a list of references. The cover page should contain your name, the title of the research project, the name and affiliation of the supervisor, the starting- and end-date of your project and the date of submission of the report. A typical report is about 5 to 10 pages incl. figures, excl. references and appendix (when using font size 11, single line spacing, a margin of min 1.5 cm all sides). A PDF of your report must be given supervisor in due time (see below). **Oral presentation** You will give an oral presentation of the results of your Research Project to the corresponding supervisor (typically including the research group of the supervisor). **Timeframe** Each research project is awarded 15 ECTS, which is equivalent to about 11.25 weeks of full-time work. This includes all preparatory work, lab work, analysis work, report writing as well as preparing and giving the oral presentation. All Research Projects must be finished within 13 weeks after they were started (excluding the Christmas break, if applicable) and you must submit a PDF of your written report to the program coordinator not later than 13 weeks after you started your Research Project. The oral presentation must be given not later than 17 weeks after the start of your Research Project. You will be informed about the two deadlines on the registration/application form after approval of your project.
Course achievement
None
Examination weight
Written report (80%) and oral presentation (20%)
Teaching method
Research methods and specialized knowledge of a neuroscientific research field. The neuroscientific content depends on the topic and laboratory where the student carries out their Research Project.

Recommendation
Two Research Projects are to be passed with two different supervisors. You can choose research projects that match your specific neuroscientific interests. The lectures within the module “Advanced Topics in Neuroscience” you attended in 2nd term gave you an overview of current neuroscience research in Freiburg and can help you in choosing your lab. The organization of research projects is on your own initiative. Please get in contact with your potential future supervisors to discuss potential topics of your projects, as well as the timeline of your project. If you would like to have some advice, we will be happy to assist you in the process of finding a supervisor and a project that matches your interests. Please note that the topic of the research project must always be in the field of neuroscience. **“Internal” Research Projects** Supervised by:Professors, Privatdozenten/Privatdozentinnen, or selected group leaders (those withexamination rights) who: ■ Are members of the University of Freiburg ■ Are actively conducting research in neuroscience ■ Regularly teach in the M.Sc. Neuroscience program **“External” Research Projects** Supervised by: ■ Professors, Privatdozenten/Privatdozentinnen, or selected group leaders (thosewith examination rights) who: o Are members of the University of Freiburg o Conduct research in neuroscience, but o Do not teach in the M.Sc. Neuroscience program OR ■ Professors/Privatdozenten/Privatdozentinnen (not group leaders!) from otheruniversities or research institutions (in Germany or abroad) who: o Conduct research in neuroscienc Erasmus Program: If you plan to apply for financial support from Erasmus for a Research Project abroad, please note that the Erasmus form can only be signed after the approval of your external Research Project by the examination panel. Before starting a Research Project, it must be registered with the program coordinator and you must have received a written approval of your project. You must not start a Research Project before you have received approval for it. Please note that a Research Project that was started before approval may not be accepted later. Forms for registration of “internal” Research Projects and for applications to the examination panel for “external” Research Project are available on ILIAS. Please fill out the corresponding form, which must be signed by you and your supervisor and submit the form to the program coordinator. Please submit sufficiently early to allow some time for approval, in particular for “external” Research Project where sometimes further clarification is needed. **Changes of topic/lab** Substantial changes of topics (or even lab changes) must be requested from the examination panel within one week after the start of the Research Project at the latest. If the change of topic/lab is approved, a new date will be set for the start of the Research Project as well as for the submission of the report and the oral presentation. After the change of topic/lab, the full duration of a Research Project will be available again. more information https://ilias.uni-freiburg.de/goto.php/fold/1295032
Usability
M.Sc. Neuroscience

↑

Name of module	Number of module
Research Project II	09LE03MO-NR-2-2021
Responsible	
PD Dr. Philippe Coulon	
Faculty	
Faculty of Biology	

ECTS-Points	15.0
Workload	450 h
Hours of week	
Recommended semester	3
Duration	1
Compulsory/Elective (C/E)	Compulsory
Frequency	each term

Compulsory requirement
Foundations of Neuroscience, Methods in Neuroscience
Recommended requirement
Elective Subjects. Research Projects in some groups may require certain background knowledge and techniques taught in the Elective Subjects.

Assigned Courses					
Name	Type	C/E	ECTS	HoW	Workload

Qualification
The student ■ can carry out a neuroscientific Research Project under the supervision of an experienced researcher ■ can write a scientific report about their Research Poject ■ can give a scientific oral presentation about their Research Project ■ can explain the neuroscientific topic of their Research Project

Examination achievement
PL1: Written report (80%) PL2: Oral presentation (20%) **Written report** The written report should have the form of a short scientific paper, typically including the sections Introduction, Methods, Results and Discussion followed by a list of references. The cover page should contain your name, the title of the research project, the name and affiliation of the supervisor, the starting- and end-date of your project and the date of submission of the report. A typical report is about 5 to 10 pages incl. figures, excl. references and appendix (when using font size 11, single line spacing, a margin of min 1.5 cm all sides). A PDF of your report must be given to the supervisor in due time (see below). **Oral presentation** You will give an oral presentation of the results of your Research Project to the corresponding supervisor (typically including the research group of the supervisor). **Timeframe** Each research project is awarded 15 ECTS, which is equivalent to about 11.25 weeks of full-time work. This includes all preparatory work, lab work, analysis work, report writing as well as preparing and giving the oral presentation. All Research Projects must be finished within 13 weeks after they were started (excluding the Christmas break, if applicable) and you must submit a PDF of your written report to the program coordinator not later than 13 weeks after you started your Research Project. The oral presentation must be given not later than 17 weeks after the start of your Research Project. You will be informed about the two deadlines on the registration/application form after approval of your project.
Course achievement
None
Examination weight
Written report (80%) and oral presentation (20%)
Teaching method
Research methods and specialized knowledge of a neuroscientific research field. The neuroscientific content depends on the topic and laboratory where the student carries out their Research Project.

Recommendation
Two Research Projects are to be passed with two different supervisors. You can choose research projects that match your specific neuroscientific interests. The lectures within the module “Advanced Topics in Neuroscience” you attended in 2nd term gave you an overview of current neuroscience research in Freiburg and can help you in choosing your lab. The organization of research projects is on your own initiative. Please get in contact with your potential future supervisors to discuss potential topics of your projects, as well as the timeline of your project. If you would like to have some advice, we will be happy to assist you in the process of finding a supervisor and a project that matches your interests. Please note that the topic of the research project must always be in the field of neuroscience. **“Internal” Research Projects** Supervised by:Professors, Privatdozenten/Privatdozentinnen, or selected group leaders (those withexamination rights) who: ■ Are members of the University of Freiburg ■ Are actively conducting research in neuroscience ■ Regularly teach in the M.Sc. Neuroscience program **“External” Research Projects** Supervised by: ■ Professors, Privatdozenten/Privatdozentinnen, or selected group leaders (thosewith examination rights) who: o Are members of the University of Freiburg o Conduct research in neuroscience, but o Do not teach in the M.Sc. Neuroscience program OR ■ Professors/Privatdozenten/Privatdozentinnen (not group leaders!) from otheruniversities or research institutions (in Germany or abroad) who: o Conduct research in neuroscienc Erasmus Program: If you plan to apply for financial support from Erasmus for a Research Project abroad, please note that the Erasmus form can only be signed after the approval of your external Research Project by the examination panel. Before starting a Research Project, it must be registered with the program coordinator and you must have received a written approval of your project. You must not start a Research Project before you have received approval for it. Please note that a Research Project that was started before approval may not be accepted later. Forms for registration of “internal” Research Projects and for applications to the examination panel for “external” Research Project are available on ILIAS. Please fill out the corresponding form, which must be signed by you and your supervisor and submit the form to the program coordinator. Please submit sufficiently early to allow some time for approval, in particular for “external” Research Project where sometimes further clarification is needed. **Changes of topic/lab** Substantial changes of topics (or even lab changes) must be requested from the examination panel within one week after the start of the Research Project at the latest. If the change of topic/lab is approved, a new date will be set for the start of the Research Project as well as for the submission of the report and the oral presentation. After the change of topic/lab, the full duration of a Research Project will be available again. more information https://ilias.uni-freiburg.de/goto.php/fold/1295032
Usability
M.Sc. Neuroscience

↑

Name of module	Number of module
Master Thesis	09LE03MO-NT-2021
Responsible	
PD Dr. Philippe Coulon	
Faculty	
Faculty of Biology	

ECTS-Points	30.0
Workload	900 h
Hours of week	
Recommended semester	4
Duration	1
Compulsory/Elective (C/E)	Compulsory
Frequency	each term

Compulsory requirement
Only students who are enrolled in the master's degree program in Neuroscience and have successfully completed the modules **Foundations of Neuroscience, Methods in Neuroscience, Research Project 1 and Research Project 2** can be admitted to the master's thesis.

Assigned Courses					
Name	Type	C/E	ECTS	HoW	Workload

Contents
In the master’s thesis module students conduct an independent research project under academic supervision. Students will apply the theoretical knowledge and methodological skills acquired during their studies, complemented by additional expertise and techniques developed in the course of the thesis, to address a defined neuroscientific research question.
Qualification
Students are able to: ■ conduct independent scientific research in neuroscience or disciplines. ■ present their research comprehensively in a written report in scientific style and format appropriate for the discipline and work conducted ■ summarise and discuss their scientific work in an oral presentation, respond to questions, and engage in professional scientific discussion with peers.

Examination achievement
Written report and oral defence (colloquium) as separate examinations. The module grade the report is determined by weighting the written thesis at 80% and the oral defence at 20% The master's thesis must be completed within a period of six months and is worth 27 ECTS credits. The master’s thesis is supplemented by a presentation of the thesis in a thesis colloquium. The presentation of the master’s thesis, for which 3 ECTS credits are awarded, has a total duration of approximately 45 minutes and consists of a presentation of no more than 20 minutes on the thesis, followed by a technical discussion of the thesis and related questions from the corresponding field of study. More information: https://ilias.uni-freiburg.de/goto.php/fold/1295034
Course achievement
'-
Grading
Written report (80%) and oral presentation (20%)
Teaching method
Independent research under supervision.
Usability
M.Sc. Neuroscience

↑