Fakultät für Biologie

Module description

Master of Science in the subject Neuroscience
(Examination regulations version 2021)

First Semester:

Module 1: Foundations of Neuroscience
Module 2: Methods in Neuroscience

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Prolog

Kurzbeschreibung Studiengang und Lehreinheit:

Fach	Neuroscience
Abschluss	Master of Science (M.Sc.)
Studiendauer	120 ECTS / 4 semester
Studienform	Full-time
Art des Studiengangs	Second degree with research thesis
Hochschule	Albert-Ludwigs-Universität Freiburg
Fakultät	Fakultät für Biologie
Internetseite	https://www.mscneuro.uni-freiburg.de/
Profil des Studiengangs	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.
Ausbildungsziele / Qualifikationsziele des Studiengangs	*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
Sprache(n)	Classes and examinations in the Neuroscience Master's 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's thesis has to be written in English. In justified cases and upon request, the student may be permitted to write the Master's thesis in German; in this case, the Master's thesis must include a summary in English.
Zugangs-voraussetzungen	(1) 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. (2) The applicant must provide documentation that, within the framework of his/her studies for a first degree from an institution of higher education (paragraph (1) sentence 1 no. 1), which requires the completion of a total of 100 ECTS credit points' worth of coursework and assessment in the fields of mathematics, computer science, natural science or engineering, at least 80 ECTS credit points have been obtained at the time of application already; of those at least 20 ECTS credit points must be from the fields of mathematics or physics. The selection committee decides on the recognition of achievements which are comparable to the requirements of sentence 1.
Einschreibung zum Sommer- und/oder Wintersemester	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

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

ECTS-Points	12.0
Hours of week	10.0
Recommended semester	1
Duration	1
Pflicht/Wahlpflicht (P/WP)	compulsory
Attendance	122 h
Independent study	238 h
Workload	360 h
Frequency	only in the winter term

Compulsory requirement
None

Assigned Courses					
Name	Type	P/WP	ECTS	HoW	Workload
From membrane to brain	lecture course	compulsory	4.0	4.0	120 hours
Physiology, anatomy and behavior of neuronal systems	excercise course	compulsory	5.0	4.3	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 in exercises ■ Successful completion of exercises ■ Regular participation in the seminar
Recommendation
In diesem Modul werden keine Tiere verwendet, die unter die Genehmigungspflicht des Tierschutzgesetzes fallen.
Usability
M.Sc. Neuroscience

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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
Faculty	
Fakultät für Biologie	

ECTS-Points	4.0
Hours of week	4.0
Recommended semester	1
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	46 h
Independent study	74 h
Workload	120 hours

Content

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

- understand and summarize the contents of the listed textbook chapters 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 at the end of the module on the contents of the lecture
Course achievement
■ Attendance of the lecture is voluntary, but highly recommended. ■ Studying the contents of the lecture and deepening the knowledge with help of the textbooks.
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
■ Lecture ■ Media: Textbooks, Blackboard, Slide Presentations, Video Clips

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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
Faculty	
Fakultät für Biologie	

ECTS-Points	5.0
Hours of week	4.3
Recommended semester	1
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	50 h
Independent study	100 h
Workload	150 hours

Content
In this practical course, first practical experience in basic neurobiology will be gained in the following 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 ■ 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. ■ observing and quantifying animal behavior in conjunction with optogenetic modulation of ongoing neuronal activity and training in the basics of neurogenetic tools, behavioral experiments.
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.

Learning target
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. ■ can prepare a simple neuroanatomical sample, perform basic staining procedures, and make drawings of the observed anatomical structures. ■ can use this acquired knowledge, insights and skills to read, understand and critically discuss scientific publications in the experimental neurosciences. ■ improve their ability to work in small teams.
Examination achievement
none
Course achievement
■ Regular participation in exercises (no absence permitted) ■ Independent self-studies during waiting times in the exercises ■ Successful completion of exercises
Literature
■ Hermey et al.: „Der Experimentator: Neurowissenschaften“, Spektrum Akademischer Verlag Heidelberg 2010, Chapters 5-7 ■ Course scripts are provided ■ Robertson, RM. 1992, Sensory adaptation: extracellular recording from locust wing hinge stretch receptor, Advan in Physiol Edu 263:S7
Compulsory requirement
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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.

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

ECTS-Points	3.0
Hours of week	1.7
Recommended semester	1
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	26 h
Independent study	64 h
Workload	90 h

Content
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

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Name of module	Number of module
Methods in Neuroscience	09LE03MO-NM-2021
Responsible	
Prof. Dr. Carsten Mehring	
Faculty	
Fakultät für Biologie	

ECTS-Points	18.0
Hours of week	14.0
Recommended semester	1
Duration	1
Pflicht/Wahlpflicht (P/WP)	compulsory
Attendance	185 h
Independent study	390 h
Workload	540 h
Frequency	only in the winter term

Compulsory requirement
None

Assigned Courses					
Name	Type	P/WP	ECTS	HoW	Workload
Scientific Programming in Python	excercise course	compulsory	3.0	2.0	90 h
Quantitative Methods and Statistics in Neuroscience	excercise course	compulsory	9.0	7.0	270 h
Neurophysiology I: Measurement and Analysis of Neuronal Activity	excercise course	compulsory	6.0	4.0	180 h

Content
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 I: Measurement and Analysis of Neuronal Activity): Individual written reports on the exercises and tasks in the electronics part and on the data analysis part by the due date.
Course achievement
SL (Scientific Programming in Python): Regular participation in discussion of exercises; Passing a written exam (2.0 hours)
Recommendation
In diesem Modul werden keine Tiere verwendet, die unter die Genehmigungspflicht des Tierschutzgesetzes fallen.
Usability
M.Sc. Neuroscience

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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
Faculty	
Fakultät für Biologie	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	1
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	30 h
Independent study	60 h
Workload	90 h

Content

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
- Passing a written exam (2 hours)

Literature

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

See 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 (see http://scipy.org/).
Compulsory requirement
None
Teaching method
Lectures, students independently solve programming tasks on the computer

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

ECTS-Points	9.0
Hours of week	7.0
Recommended semester	1
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	100 h
Independent study	170 h
Workload	270 h

Content

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

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

ECTS-Points	6.0
Hours of week	4.0
Recommended semester	1
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	80 h
Independent study	100 h
Workload	180 h

Content
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

Learning target
■ The students understand 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 ■ The students understand standard neurophysiological analysis tools and write own functions for the analysis of neurophysiological data in Matlab.
Examination achievement
Individual written reports on the exercises and tasks in the electronics part and on the data analysis part by the due date.
Course achievement
none
Compulsory requirement
none
Teaching method
Lectures, exercises, independent group work

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