Module Handbook for degree programme „MSc Integrative Neuroscience“

General aims

The degree programme “MSc Integrative Neuroscience” is aimed at exceptionally able and motivated students who wish to pursue a career in neuroscience research. It is ‘integrative’ in the sense that it covers an unusually broad and interdisciplinary spectrum of neuroscience research. In the master thesis, students perform an independent research project, based on the knowledge, understanding and skills conveyed by the course programme. Thus, the educational aim is that students become able to independently address complex scientific problems and to generate original solutions beyond the current state of knowledge (EQF level 7). The course programme is taught by more than 50 active neuroscience researchers, in keeping with the German tradition of unified research and teaching. In addition, the programme follows the current best-practice in the European Higher Education Area in conveying knowledge and understanding in neuroscience, practical and applied skills in neuroscience, as well as broader professional competencies.

Programme structure

The course programme comprises 120 credit points (CP) in total and divides into two study segments plus a master thesis. The first and larger study segment (60 CP) consists mainly of core courses (obligatory lectures and practical courses) and conveys *fundamental* knowledge and understanding plus practical and applied skills in three areas of neuroscience:

A Fundamental molecular and cellular neuroscience
B Fundamental systems and behavioural neuroscience
C Fundamental theoretical and computational neuroscience

Additional elective courses (tutorials and exercises) help students to address any deficiencies in their prior knowledge. Such deficiencies are to be expected and indeed unavoidable, given that participants obtained their first degrees in very different fields. The second and smaller study segment (30CP) consists mainly of elective courses (lectures and practical courses) and conveys *advanced* knowledge and understanding plus practical and applied skills in four areas of neuroscience:

A Advanced molecular and cellular neuroscience
B Advanced systems and behavioural neuroscience
C Advanced theoretical and computational neuroscience
D Advanced clinical and applied neuroscience

For the master thesis (30CP), students participate in the ongoing work of one of the research institutes and have the opportunity to take part in research seminars (4 CP optional).

Knowledge, skills and competences

In addition to specific knowledge and skills in neuroscience, all parts of the course programme also teach broader competencies (‘key competencies’) such as making independent judgements, learning in a self-directed manner, and communicating to scientific and general audiences. Courses that specifically concern key competencies are combined into Module X "Professional key competencies" (15 CP obligatory, 12 CP elective and optional). In addition, many integral components of other courses – such as practical courses, tutorials, seminars, homework assignments, and seminar presentations – contribute also to the acquisition of broader competencies. These integral components comprise 14 CP obligatory practical work, 16 CP elective practical work, and 14 CP elective and optional tutorials.

In summary, approximately 40% of the 144 offered credits concern neuroscientific knowledge and understanding, approximately 21% concern a combination of neuroscientific skills and key competencies, approximately 18% are dedicated specifically to key competencies, and approximately 21% to the master thesis.

Knowledge and skills in neuroscience	57 Credits (40%)
Key competencies (integrated with other courses)	16-32 Credits (21%)
Key competencies (in dedicated courses)	15-25 Credits (18%)
Master thesis	30 Credits (21%)

Module descriptions

This handbook describes all modules of the degree programme “MSc Integrative Neuroscience”. Each module description specifies

- Module aims and learning outcomes
- Teaching formats
- Status within the programme (obligatory, elective, optional)
- Semesters offered, duration
- Prerequisite for participation
- Time investment (face-to-face and independent study)
- Credit points
- Assessment and examinations
- Module coordinators and module lecturers
- Recommended literature

Other courses

In addition to the courses offered, students may apply to receive credit for courses offered in the context of other master degree programmes, provided these are relevant to neuroscience and award the same number of credits (5 CP). However, students are cautioned to beware of possible schedule conflicts.

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Degree programme:
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Module GA101 (5 CP obligatory und 2 CP elective):
Cellular Neurophysiology

Module aims and learning outcomes:
At the end of the module, students will have fundamental knowledge and understanding in cellular neurophysiology. Specifically, they will be able to recognise, organise and explain the components and cellular organelles of neurons and glia, the major signalling pathways, the microstructure and electrophysiology of neuronal specializations (e.g., dendrites, axons, and synapses), basic mechanisms of synaptic plasticity, cellular mechanisms of information storage, and alternative possibilities of information encoding. In addition, students will have acquired fundamental practical and applied skills in cellular neurophysiology. Specifically, they will be able to explain, demonstrate, and apply electronic recording equipment and extracellular recording from hippocampal slice preparations. Furthermore, in performing laboratory experiments and preparing a professional report, students will have acquired broader competencies in judging complex information, learning independently, and communicating in a scholarly context.

Module assessment:
The course material is assessed in the form of a lab report and a written exam, to offer detailed feedback about learning performance. Based on this feedback, students can identify and remedy any deficiencies before progressing to module GA111.

Obligatory lecture and practical:
Cellular mechanisms of the electrical excitability of nerve cells and the transmission of excitation and information between nerve cells. Axonal and synaptic transmission of excitation, neurotransmitters, neuromodulators, the basis of neuronal learning, and fundamental research methods. Specific topics covered are excitable cells, axonal transmission, synaptic transmission, intracellular signal pathways, neuromodulators and hormones, function and electrical properties of glia cells and muscles, alternative possibilities of information storage, the plasticity of synapses, pathophysiology of nerve cells, and modern methods of neurophysiology.

The practical consists of introducing electronic measurement techniques and an experiment to record extracellular activity in cortical slices.
The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in cell physiology.

Elective tutorial:
Students with a weaker background in cell biology are encouraged to attend the elective tutorial. It offers the opportunity for further discussion of any additional questions about the lecture materials.

Teaching formats:
1 obligatory lecture and practical (4 SWS)
1 elective tutorial (2 SWS).
All taught in English.

Semesters offered:
every winter semester
Duration:
1 semester

Prerequisite for participation:
First degree in a biological field or introductory course in biochemistry.

Time investment core components:
Face-to-face: 56h (=4 SWS). Independent study: 96h. Total: 150h (=5 CP).
Time investment elective components:
Face-to-face: 14h (=1 SWS). Independent study: 46h. Total: 60h (=2 CP).

Credit points:
Total number of credit points: 5 CP obligatory plus 2 CP elective

Examinations:
written exam 120 min (K120); 101 practical: lab report (EB)

Module coordinators:
Prof. Oliver Stork

Module lecturers:
Prof. V Leßmann, PD C. Seidenbecher, Prof. O. Stork, Prof. F. Schaper,
Dr. T. Munsch, and others.

Recommended literature:
Brady, Siegel, et al., “Basic Neurochemistry: Principles of Molecular, Cellular and Medical Neurobiology”. Academic Press Inc. (2012)
Hammond, “Cellular and Molecular Neurophysiology”. Academic Press Inc. (2008)

General:
Unit I of Purves, Augustine at al., eds., “Neuroscience”, 5th edition, 2011.
Parts II and III of Kandell, Schwartz, Jessell, “Principles of Neural Science”, 5th edition, 2012.

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Module GA102 (5 CP obligatory and 2 CP elective): **Basic molecular and cell biology**
Module aims and learning outcomes: At the end of the module, students will have fundamental knowledge and understanding of molecular and cell biology and their relevance to neuronal cells. Specifically, they will be able to recognise, organise and explain the molecular components of neurons and glia, the major biochemical processes in these cells, metabolic and signalling pathways, the molecular microstructure and function of neuronal specializations (e.g., dendrites, axons, and synapses), molecular mechanisms of synaptic plasticity and information storage. In addition, students will have acquired fundamental practical and applied skills in molecular and cell biology. Specifically, they will be able to explain, demonstrate, and apply biochemical analysis reagents, molecular cloning techniques, and state-of-the-art molecular and genetic intervention approaches. Furthermore, in performing laboratory experiments and preparing a professional report, students will have acquired broader competencies in judging complex information, learning independently, and communicating in a scholarly context. **Module assessment:** The course material is assessed in the form of a lab report and a written exam, to offer detailed feedback about learning performance. Based on this feedback, students can identify and remedy any deficiencies before progressing to module GA111. **Obligatory lecture and practical:** Foundations of general molecular and cell biology, not on neurons only, including classes of biomolecules, synthesis, transport, and disposal of cell components, cell communication, and basic methodologies of molecular and cell biology. Specific topics include bioorganic chemistry, gene expression, cytoskeleton and cell adhesion, organelle function, intracellular signalling pathways, intracellular transport, basic genetics and cellular metabolism pathways and molecular biology approaches to their analysis. The practical provides an introduction to, laboratory safety issues, good laboratory praxis and documentation of laboratory work. Experiments performed include the making of buffers and dilutions, colourimetric determination of protein concentration and the handling, transformation and growth of bacteria. An introduction is given to molecular biology databases and related bioinformatic tools. The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in cell biology, organic chemistry and biochemistry. **Elective tutorial:** Students with a weaker background in biochemistry and cell biology are encouraged to attend the elective tutorial. They offer an opportunity for further discussion of any additional questions about the lecture materials.

Students with a weaker background in biochemistry and cell biology are encouraged to attend the elective tutorial. They offer an opportunity for further discussion of and additional questions about the lecture materials.

Teaching formats:
1 obligatory lecture (3 SWS)
1 obligatory practical course (2 SWS)
1 elective tutorial (1 SWS).
All are taught in English.

Semesters offered:
every winter semester
Duration:
1 semester

Prerequisite for participation:
First degree in a biological field or introductory course in biochemistry

Time investment core components:
Face-to-face: 70h (=5 SWS). Independent study: 80h. Total: 150h (=5 CP).
Time investment elective components:
Face-to-face: 14h (=1 SWS). Independent study: 46h. Total: 60h (=2 CP).

Credit points:
Total number of credit points: 5 CP obligatory plus 2 CP elective

Examinations:
written exam 120 min (K120); 102 practical: lab report (EB)

Module coordinators:
Prof. O. Stork

Module lecturers:
PD J. Bock, PD C. Seidenbecher, Prof. O. Stork, Dr. U. Thomas, and others.

Recommended literature:
Brady, Siegel, et al., "Basic Neurochemistry: Principles of Molecular, Cellular and Medical Neurobiology". Academic Press Inc. (2012)
Extended reading
Lehninger, "Principles of Biochemistry", W.H. Freeman (2008, 2012)
Lodish, Berk, et al., "Molecular Cell Biology". W. H. Freeman (2012)
General:
Unit I of Purves, Augustine at al., eds., "Neuroscience", 5th edition, 2011.
Parts II and III of Kandell, Schwartz, Jessell, "Principles of Neural Science", 5th edition, 2012.

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Module GB103 (5 CP obligatory and 2 CP elective):
Integrative & Comparative Neuroanatomy

Module aims and learning outcomes:
At the end of the module, students will have a comprehensive and fundamental knowledge of vertebrate neuroanatomy. Specifically, they will be able to recognize, organize and explain modern neuroanatomical and neurohistological approaches in neuroscience research, as well as the particular advantages and challenges of integrative approaches to the neuroanatomical bases of behaviour. The students will also be able to recognize, organize and explain vertebrate neuroanatomy (humans, primates, rodents) and different functional brain systems in considerable detail. In addition, students will have acquired further practical and applied skills in neuroanatomy and neurohistology. Specifically, they will be able to explain, demonstrate and apply various microscopic techniques of neurohistology. Furthermore, the elective tutorial allows students to acquire broader competencies in judging complex information, working independently and communicating in a scholarly context.

Module assessment:
The course material is assessed in the form of a written exam and one lab report, to offer detailed feedback about learning performance. Based on this feedback, students can identify and remedy any deficiencies before progressing to modules GB113 and GB112/114.

Obligatory lecture and practical:
This course covers the general plan of the nervous system of the most important vertebrate groups, a detailed introduction to human neuroanatomy and insight into the evolution of functional brain systems. Specific topics include a comparative view of the central nervous system of different vertebrate groups, gross and detailed human neuroanatomy (spinal cord, myelencephalon, rhombencephalon, mesencephalon, diencephalon, telencephalon, cranial and spinal nerves, transmitters systems) as well as functional systems (vegetative/autonomic, motoric, limbic, sensory and executive).

Elective tutorial:
Students with a weaker background in neuroanatomy are encouraged to attend the elective tutorial. The tutorial offers an opportunity for additional questions about the lecture materials and more detailed discussions of the addressed topics.

Teaching formats:
1 obligatory lecture (3 SWS)
1 obligatory practical (2 SWS)
1 elective tutorial (1 SWS).
All are taught in English.

Semesters offered:
every winter semester
Duration:
1 semester

Prerequisite for participation: First degree in biology, medicine, psychology, or cognitive science, or self-study of Delcomyn, “Foundations of Neurobiology”, W.H. Freeman, 1998.
Time investment core components: Face-to-face: 70h (=5 SWS). Independent study: 80h. Total: 150h (=5 CP). **Time investment elective components:** Face-to-face: 14h (=1 SWS). Independent study: 46h. Total: 60h (=2 CP).
Credit points: Total number of credit points: 5 CP obligatory plus 2 CP elective
Examinations: written exam 120 min (K120); 103 practical: lab report (EB)
Module coordinators: Prof. C. Lenschow, Apl. Prof. J. Bock **Module lecturers:** Prof. C. Lenschow, Apl. Prof. J. Bock.
Recommended literature: Gerald Schneider, "Brain Structure and its Origins", MIT Press, 2014. Eric R Kandel, Thomas M Jessell, Steven A Siegelbaum, “Principles of Neural Science”, McGraw-Hill Education, 2021. Werner Kahle, Michael Frotscher, updated by Frank Schmitz, “Color Atlas of Human Anatomy, Volume 3: Nervous System and Sensory Organs”, Thieme, 2022. Anne B. Butler, William Hoods, „Comparative Vertebrate Neuroanatomy - Evolution and Adaptation 2e“, Wiley-Liss, 2005.

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Module GC105 (5 CP obligatory):
Theoretical Neuroscience I

Module aims and learning outcomes:
After completing this module, students will have comprehensive and fundamental knowledge and understanding of theoretical and computational neuroscience of neurons and neuron populations. Specifically, they will be able to recognize, organize and explain models of individual neurons and synapses (single-compartment model, leaky integrate-and-fire model, Hodgkin-Huxley model of action potential), techniques for characterizing neuronal responsiveness and for decoding the responses of neuronal populations (tuning curves, receptive fields, psychometric and neurometric functions, signal detection theory, maximum likelihood decoding, maximum a posterior likelihood decoding), basic principles of information theory (Shannon information, entropy, mutual information, application to neuronal responses).

Furthermore, in performing the biweekly homework assignments, students will acquire extensive applied and practical skills in the analytical, mathematical, computational, and theoretical tools and approaches of contemporary neuroscience. In this effort, students are assisted by weekly tutorials held for small groups (maximum 20 students) by graduate student tutors. For students with a weaker background in mathematics, physics, and programming the tutorial will be particularly helpful.

Finally, by preparing and handing in well-written and –illustrated homework in small groups (two persons), which are assessed and returned with comments each week, students will have acquired broader competencies in judging complex information, learning independently and communicating in a scholarly context.

Module assessment:
The course material is assessed in the form of a written exam and written exercises, to offer detailed feedback about learning performance. Based on this feedback, students can identify and remedy any deficiencies before progressing to module GA115.

Obligatory lectures and tutorials:

Based on Chapters 5-6 and Chapters 1-4 of Dayan & Abbott. Electrochemical equilibrium and Nernst Equation, equivalent circuits for the single-compartment model, leaky integrate-and-fire model, Hodgkin-Huxley and Connor-Stevens models of the action potential, cable equation and neuron morphology, characterizing neuronal responses with tuning curves and receptive fields, signal-detection theory and psychometric function, comparison of neuronal and behavioural responses with neurometric function, population coding, statistically efficient decoding with maximum likelihood and maximum a posteriori likelihood, Fisher information, introduction to Shannon information, application of Shannon information to neural responses.

To develop a deeper understanding and acquire applied and practical skills, students perform weekly homework assignments with Matlab programming. A passing grade on all assignments is required for admission to the final exam.

The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in mathematics and physics.

Students with a weaker background in mathematics and physics are encouraged to attend the elective tutorial. They offer an opportunity for further discussion of any additional questions about the lecture materials.

Teaching formats:
1 obligatory lecture (3 SWS).
1 obligatory tutorial (2 SWS).
All are taught in English.

Semesters offered:
every winter semester
Duration:
1 semester

Prerequisite for participation:
First degree in physics, mathematics, or engineering, or self-study of
Gabbiani & Cox, “Mathematics for Neuroscientists”, 2010.

Time investment core components:
Face-to-face: 70h (=5 SWS). Independent study: 80h. Total: 150h (=5 CP).

Credit points:
Total number of credit points: 5 CP

Examinations:
biweekly homework assignments (HA), written exam 120 min (K120).

Module coordinators:
Prof. J. Braun

Module lecturers:
Research assistants.

Recommended literature:
Peter Dayan & Larry Abbott, “Theoretical Neuroscience”, MIT Press, 2001.
David Sterratt, Bruce Graham, Andrew Gillies, David Willshaw, “Principles of Computational Modelling in Neuroscience”, Cambridge University Press, 2011.

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Module GC 106/116 (6 CP obligatory and 4 CP elective):
Mathematics & Statistics

Module aims and learning outcomes:
Having completed this module, students will have comprehensive and fundamental knowledge and understanding of mathematics and statistics as applied to neuroscience. Specifically, students will be able to recognize, organize, and explain the mathematical foundations of neuroscience (vector algebra, integral and differential calculus, integral transforms) and of scientific statistics (random variables and distributions, hypothesis testing and inferential statistics, analysis of variance and general linear models, non-parametric analyses and bootstrapping).

Furthermore, in performing homework assignments, students will acquire applied and practical skills in the analytical, mathematical, and statistical tools and approaches of contemporary neuroscience. In this effort, students are assisted by weekly tutorials held for small groups (maximum 20 students) by graduate student tutors. For students with a weaker background in mathematics, physics, and programming the tutorial will be particularly helpful.

Module assessment:
The course material is assessed in the form of two written exams, to offer detailed feedback about learning performance. Based on this feedback, students can identify and remedy any deficiencies before progressing to module VC.

Elective tutorials:
Students with a weaker background in mathematics and physics are encouraged to attend the elective tutorial. They offer an opportunity for further discussion of any additional questions about the lecture materials.

Module components:
<u>106 Mathematical foundations (2 SWS obligatory lectures and 2 SWS elective tutorials)</u>

Differential and integral calculus and vector algebra, insofar as relevant to neuroscience. n-dimensional Euclidian space, matrix algebra, linear equations, determinants, eigenvalues and –vectors, complex numbers, linear differential equations, the exact solution of simple LDEs, functions of several variables, partial derivative and gradient, local extrema, optimization with boundary conditions.

The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in mathematics.

<u>116 Advanced Statistics for Neuroscience (2 SWS obligatory lectures and 2 SWS elective tutorials)</u>
Central concepts of statistics and probability theory, insofar as relevant to neuroscience. Descriptive statistics, probability, inferential statistics, estimation and hypothesis testing, analysis of variance, correlation and regression, general linear

models, non-parametric methods and bootstrapping, applied to neuroscience examples.

The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in mathematics and statistics.

Teaching formats:
2 obligatory lectures (2 SWS each)
2 elective tutorials (2 SWS each)
All taught in English.

Semesters offered:
106 every winter semester
116 every summer semester
Duration:
1 semester each

Prerequisite for participation:
First degree in physics, mathematics, or engineering, or self-study of
Gabbiani & Cox, "Mathematics for Neuroscientists", 2010.

Time investment core components:
Face-to-face: 56h (=4 SWS). Independent study: 124h. Total: 180h (=6 CP).
Time investment elective components:
Face-to-face: 56h (=4 SWS).. Independent study: 64h. Total: 120h (=4 CP).

Credit points:
Total number of credits 6 CP obligatory and 4 CP elective
106: 3 CP lecture plus 2 CP tutorial
116: 3 CP lecture plus 2 CP tutorial

Assessment and examinations:
Mastery of the course materials is assessed in homework assignments (HA) and in written examinations (K120). Tutorials are not assessed. Homework assignments are assessed as pass/fail. Students must pass all assignments to be admitted to the written exam. Written exams are graded.
106 lecture: weekly homework assignments (HA), written exam 120 min (K120).
116 lecture: weekly homework assignments (HA), written exam 120 min (K120).

Module coordinators:
Prof. B. Nill, Prof. K. Krug

Module lecturers:
Prof. B. Nill and others

Recommended literature:
106:
Edward Batschelet, “Introduction to Mathematics for Life Scientists”, Springer, 3rd Edition, 2015.
Fabrizio Gabbiani & Steven Cox, “Mathematics for Neuroscientists”, Academic Press, 2nd Edition, 2017.
Bart Ermentrout & David Terman, “Mathematical Foundations of Neuroscience”, Springer, 2010th Edition, 2010.

116:
Sheldon Ross, “Introduction to Probability and Statistics for Engineers and Scientists”, Academic Press, 6th Edition, 2020.
Susan Holmes & Wolfgang Huber, "Modern Statistics for Modern Biology", Cambridge University Press, 2019.

Degree programme: **MSc Integrative Neuroscience**
Module GA111 (5 CP obligatory and 2 CP elective): **Molecular & Cellular Neurobiology**
Module aims and learning outcomes: At the end of the module, students will have comprehensive and fundamental knowledge and understanding of molecular and cellular neuroscience. Specifically, they will be able to recognize, organize and explain modern molecular and cellular approaches to neuroscience research, including molecular and cellular agents of cell motility, signal transduction, cell development, cell communication, and further aspects of bioinformatics. Similarly, students will be able to recognize, organize and explain the embryonic development of the vertebrate brain and the various mechanisms for forming, pruning and reorganizing synaptic connections ('plasticity'). They will be able to integrate these into systems-level functions, including neuronal network activities, behavioural adaptation and interactions with peripheral signals. In addition, students will have acquired further practical and applied skills in molecular and cellular neuroscience. Specifically, they will be able to explain, demonstrate and apply important experimental methods of molecular and cellular biology to the analysis of neuronal processes. Furthermore, in performing the laboratory experiments and preparing a professional report, students will have acquired broader competencies in judging complex information, learning independently and communicating in a scholarly context. **Module assessment:** The course material is assessed in the form and a lab report and a written exam, to offer detailed feedback about learning performance. Based on this feedback, students can identify and remedy any deficiencies before progressing to modules VA and VD. **Obligatory lecture and practical:** Current research approaches to the nervous system with biochemical and molecular methods. Gene expression, modern methods of molecular neurobiology, molecular aspects of neural development, molecular motors of motility and migration, channels and receptors, neurosecretion, neuromodulatory mechanisms, molecular sensory physiology, advanced aspects of bioinformatics, and diagnostic applications. In the practical course, students apply important methods such as molecular cloning, biochemistry of proteins, Southern, Northern, and Western Blotting, polymerase chain reactions, and bioinformatic analysis and information tools. **Elective tutorial:** The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. Moreover using current literature in the field, principle approaches to molecular and cellular neuroscience and recent developments in the field will be discussed.
Teaching formats: 1 obligatory lecture and practical (4 SWS) 1 elective tutorial (2 SWS) All taught in English.

Semesters offered: Every summer semester **Duration:** 1 semester
Prerequisite for participation: none
Time investment core components: Face-to-face: 56h (=4 SWS). Independent study: 94h. Total: 150h (=5 CP). **Time investment elective components:** Face-to-face: 28h (=2 SWS). Independent study: 32h. Total: 60h (=2 CP).
Credit points: Total number of credit points: 5 CP obligatory and 2 CP elective
Assessment and examinations: Mastery of the course materials is assessed in a written examination (K120) for the lecture and in a lab report (EB) for the practical course. Tutorials are not assessed. All assessments are graded. lecture: written exam 120 min (K120); practical course: lab report (EB)
Module coordinators: Prof. O. Stork **Module lecturers:** Prof. O. Stork, Prof. V. Leßmann, Prof. C. Seidenbecher, Apl. Prof. J. Bock, Dr. U. Thomas, Dr. T. Munsch, and others
Recommended literature: Brady, Siegel, et al., “Basic Neurochemistry: Principles of Molecular, Cellular and Medical Neurobiology”. Academic Press Inc. (2012) Hammond, “Cellular and Molecular Neurophysiology”. Academic Press Inc. (2008) General: Unit I of Purves, Augustine at al., eds., “Neuroscience”, 5th edition, 2011. Parts II and III of Kandell, Schwartz, Jessell, “Principles of Neural Science”, 5th edition, 2012.

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Module GB113 (5 CP obligatory): **Systems Neurophysiology**
Module aims and learning outcomes: At the end of the module, students will have comprehensive and fundamental knowledge and understanding of systems and behavioural neuroscience. Specifically, they will be able to recognize, evaluate and explain modern physiological, anatomical, imaging and behavioural approaches in neuroscience research, as well as the particular advantages and challenges of integrative approaches to investigating the neurobiological bases of behaviour. They will be able to recognize, organize and explain mammalian neuroanatomical and functional brain systems in considerable detail (especially visual, auditory, somatosensory and motor systems). They will acquire a fundamental understanding of encoding and manipulating sensation and behaviour at the level of single neurons and circuits. In addition, students will learn further practical and applied skills in single-unit neurophysiology. Specifically, they will be able to explain, demonstrate and apply extra- and intracellular single-unit and/or patch-clamp recording techniques. Furthermore, in performing the laboratory experiments and preparing a professional report, students will have acquired broader competencies in judging complex information, learning independently and communicating in a scholarly context. **Module assessment:** The course material is assessed in the form of one written exam and one lab report as pre-requisite to sit the exam, to offer detailed feedback about learning performance. Based on this feedback, students can identify and remedy any deficiencies before progressing to modules VA and VD. **Practical work:** The practical course is currently offered in five versions, taught by different research groups. **Obligatory lecture and practical:** **<u>113 Systems neurophysiology (3 SWS lectures, 2 SWS practical work, both obligatory)</u>** Covers functionally important principles of brain circuits and deepens, building on 103, the functional anatomy and physiology of selected brain systems, with a particular emphasis on primates and some direct comparison to other mammalian systems. Specific topics include cell types and circuits in the neocortex and archicortex of primates, cortical areas, connectivity and hierarchies. In-depth treatment of the visual system (retina, LGN, striate cortex, ventral pathway, dorsal pathway), somatosensory system (touch, temperature, pain and receptors), auditory system (inner ear, auditory nerve, cochlear nucleus, olivary nuclei, inferior colliculus, auditory cortex), motor system (muscles and motor units, spinal reflexes, motor cortex and motor planning, basal ganglia and cerebellum).
Teaching formats: 1 obligatory lecture and practical (5 SWS) All taught in English.

Semesters offered: Every summer semester **Duration:** 1 semester
Prerequisite for participation: none
Time investment core components: Face-to-face: 70h (=5 SWS). Independent study: 80h. Total: 150h (=5 CP).
Credit points: Total number of credits: 5 CP obligatory
Assessment and examinations: Mastery of the course materials is assessed in a written examination (K120) for the lecture and in lab reports (EB) for the practical. written exam 120 min (K120); 113 practical: lab report (EB)
Module coordinators: Prof. K. Krug **Module lecturers:** Prof. K. Krug, Prof. C. Lenschow, Dr. M. Brosch, and others
Recommended literature: Parts IV and V in Kandell, Koester, “Principles of Neural Science”, 6th edition, 2021 Units II and III in Augustine, Groh at al., eds., “Neuroscience”, 6th edition, 2018

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Module GB112/114 (5 CP obligatory and 2 CP elective):
Development & Learning

Module aims and learning outcomes:
At the end of the module, students will have comprehensive and fundamental knowledge and understanding in molecular and cellular aspects of neurodevelopment. Students will be able to recognize, organize and explain embryonic and neuronal development and the various mechanisms for forming, pruning and reorganizing synaptic connections (‘plasticity’). In addition, students will have acquired further skills in molecular and cellular neuroscience and an understanding of environmentally driven development and neurodevelopmental disorders.

At the end of the module, students will have fundamental knowledge and understanding of comparative systems and behavioural neuroscience. Specifically, they will be able to recognize and explain modern neuroanatomical, neurophysiological and behavioural approaches in neuroscience research to study the neurobiological bases of learning and memory across species. Having completed this module, students will thus have advanced knowledge and understanding of mnemonic systems, defined by animal and human research paradigms that are fundamental to the organization of adaptive behaviour, and how they can organize research into these topics.

Module assessment:
112: The course material is assessed in the form of one written exam, to offer detailed feedback about learning performance. Based on this feedback, students can identify and remedy any deficiencies before progressing to modules VB and VD.

114: The course material is not graded.

Elective tutorial:
112: The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in developmental biology.

Module components:
<u>**112 Development and plasticity (2 SWS obligatory lectures and 2 SWS elective tutorials)**</u>
The course covers several aspects of neuronal development with a focus on the vertebrate brain. Topics include early stages of embryonic development, neural tube formation, inductive signals, neuronal identity (stem cells) and differentiation, cell proliferation and cell death, cell migration, axon growth and pathfinding. Specific topics focus on mechanisms of forming, pruning and reorganizing synaptic connectivity. In addition, environmentally driven developmental processes will be addressed with a specific focus on fetal programming, developmental origins of health and disease, neurodevelopmental disorders and adaptive plasticity. Within this context, epigenetic mechanisms will be discussed.

The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in developmental biology. - **114 Learning and memory (3 SWS obligatory seminars)** The course will give a comprehensive overview of the neurobiological bases of learning and memory across species with emphasis on *Drosophila melanogaster*, rats, mice, and humans as well as non-human primates. The course will introduce the role of memory in the behavioural organization and fundamental concepts of different forms of learning, memory and cognition in animals and humans. Specific topics include non-associative and associative conditioning, the formation of engrams and how they can impact behaviour, working and perceptual memory, the organization of memory phases, spatial memory and navigation, the role of dopamine and reinforcement learning, and the preservation and decline of human memory in ageing and dementia. **This course offers exemplary glimpses of more advanced research topics rather than foundational knowledge and understanding.**
Teaching formats: 2 obligatory lectures (2 SWS or 3 SWS each). 1 elective tutorial (2 SWS). All are taught in English.
Semesters offered: Every summer semester **Duration:** 1 semester
Prerequisite for participation: none
Time investment core components: Face-to-face: 70h (=5 SWS). Independent study: 80h. Total: 150h (=5 CP). **Time investment elective components:** Face-to-face: 28h (=2 SWS). Independent study: 32h. Total: 60h (=2 CP).
Credit points: *Total number of credit points: 5 CP obligatory and 2 CP as elective* *112:* 2 CP obligatory lecture plus 2 CP tutorial, as elective *114:* 3 CP obligatory lecture
Assessment and examinations: Mastery of the course materials is assessed in a written examination (K120) for lecture 112. Tutorial is not assessed. All assessments are graded. 112 lecture: written exam 120 min (K120) 114 lecture: not graded.

Module coordinators:
apl. Prof. J. Bock, Prof. B. Gerber

Module lecturers:
Prof. B. Gerber, apl. Prof. J. Bock, Dr. A. Maaß, and others.

Recommended literature:

112:

Marta C. Antonelli, “Perinatal Programming of Neurodevelopment (Advances in Neurobiology 10)”, Springer, 2016.
Luis Maria Vaschetto, “Epigenetics, Development, Ecology and Evolution”, Springer, 2022.
Michael Barresi, Scott Gibert, “Developmental Biology”, Oxford University Press, 2023

114:

Cobb, Matthew:
The idea of the brain: a history. – London: Prilfe Books, 2020
ISBN: 978-1-78125-589-6

Scientists making a difference: one hundred eminent behavioral and brain **scientists** talk about their most important contributions /ed. by Robert J. Sternberg … - New York: Cambridge University Press, 2016
ISBN: 978-1-107-56637-8 (pbk); 978-1-10712713-5 (hbk)

Principles of neural science / ed. by Eric R. Kandel… - 6th. Ed. – New York u.a.: McGraw-Hill, 2021
ISBN: 978-1-259-64223-4

Swanson, Larry W.:
Brain Architecture: Understanding the basic plan. – 2nd Ed. – Oxford: Oxford University Press, 2012
ISBN: 978-0-19-537858-0

Neurosciences – from molecule to behavior. – Ed. C. Giovanni Galizia… – Berlin : Springer Spektrum, 2013
ISBN: 978-3-662-51881-6

Lieberman, David A.:
Learning and Memory. – 2nd Ed. – Cambridge: Cambridge University Press, 2021
ISBN: 978-1-108-45073-7

Berkowitz, Ari:
Governing behavior. – Cambridge: Harvard University Press, 2016
ISBN: 978-0-674-73690-0

Greenspan, Ralph J.:
An introduction to nervous systems. – Cold Spring Harbor: Cold Spring Harbor Laboratory Press, 2007
ISBN: 978-0-87969-821-8

Hohwy, Jakob:
The predictive mind. – Oxford: Oxford University Press, 2013
ISBN: 978-0-19-968673-5

Llinás, Rodolfo R.:
I of the vortex: from neurons to self. – Cambridge, Mass.: MIT Press, 2002
ISBN: 978-0-262-62163-2

Degree programme:
MSc Integrative Neuroscience

Module GC115 (5 CP obligatory)
Theoretical Neuroscience II (Networks)

Module aims and learning outcomes:
After completing this module, students will have comprehensive and fundamental knowledge and understanding in theoretical and computational neuroscience. Specifically, they will be able to recognize, organize and explain models of neuronal network dynamics (state-space analysis and eigenvalue analysis of steady-states), models of Hebbian plasticity and associative learning (activity-driven plasticity), current models of conditioning and reinforcement learning (Rescorla-Wagner, temporal-difference, actor-critic), and models of representational learning and generative models (expectation maximization, principal components, independent components).

Furthermore, in performing the weekly homework assignments, students will acquire extensive applied and practical skills in the analytical, mathematical, computational, and theoretical tools and approaches of contemporary neuroscience. In this effort, students are assisted by weekly tutorials held for small groups (maximum 15 students) by graduate student tutors. For students with a weaker background in mathematics, physics, and programming the tutorial will be particularly helpful.

Finally, by preparing and handing in well-written and –illustrated homework in small groups (two persons), which are assessed and returned with comments each week, students will have acquired broader competencies in judging complex information, learning independently and communicating in a scholarly context.

Module assessment:
The course material is assessed in the form of a written exam and written exercises, to offer detailed feedback about learning performance. Based on this feedback, students can identify and remedy any deficiencies before progressing to advanced modules such as VC223.

Module component:
115 Theoretical neuroscience II (3 SWS lectures and 2 SWS tutorials)
Based on Chapters 7-10 of Dayan & Abbott. Rate models of network dynamics, synaptic plasticity, reinforcement learning, and generative models. Linear models of neural networks, dynamic analysis of state-space, eigenvalue analysis of steady-states, models of activity-dependent plasticity, associative learning with neural networks, modern theories of reinforcement learning (Rescorla-Wagner, temporal-difference, actor-critic models), and abstract approaches to representational learning and generative models (expectation maximization, principal components, independent components).

To develop a deeper understanding and to acquire applied and practical skills, students perform weekly homework assignments with Matlab programming. A passing grade on all assignments is required for admission to the final exam.

The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in mathematics and physics.

Teaching formats:
1 obligatory lecture (3 SWS).
1 obligatory tutorial (2 SWS).
All are taught in English.

Semesters offered:
Every summer semester

Prerequisite for participation:
none

Time investment core components:
Face-to-face: 70h (=5 SWS). Independent study: 80h. Total: 150h (=5 CP).

Credit points:
Total number of credit points: 5 CP, obligatory

Examinations:
written exam 120 min (K120), weekly homework assignments (HA).

Module coordinators:
Prof. J. Braun

Module lecturers:
Prof. J. Braun

Recommended literature:
Peter Dayan & Larry Abbott, "Theoretical Neuroscience", MIT Press, 2001.
Hugh Wilson, "Spikes, Decisions, Actions: the Dynamical Foundations of Neuroscience", Oxford University Press, 1999.
Richard Sutton & Andrew Barto, "Reinforcement Learning: an Introduction", Bradford Books, 2nd Edition, 2018.

Degree programme: **MSc Integrative Neuroscience**
Module VA201 (5 CP elective seminars and practicals) **Genetic Models**
Module aims and learning outcomes: Having taken this elective course, students will have advanced knowledge and understanding of genetic model systems. Specifically, they will be able to recognize, organize and explain the production and application of mutants to the study of neurobiological function and dysfunction. **Module assessment:** The course material is assessed in the form of a short lab report and an oral presentation, to offer detailed feedback about learning performance. - **Practical work:** All module components include practical lab work in addition to lectures. Working mostly independently (but under supervision) and in small groups, students acquire practical and applied skills as well as a range of broader competencies in critical analysis and synthesis of complex information (‘judging’) and in assuming responsibility for, and leadership of, joint research projects (‘communicating’).
Module component: **<u>201 Genetic models (1 SWS seminars, 2 SWS practical work, both elective)</u>** Analysis of genetic variants and rare genetic diseases in humans. Design, development and analysis of genetic models in combination with viral intervention technology to study physiological and pathophysiological neural processes. The practical part introduces to methods of gene mutation analysis, morphological, biochemical and behavioural phenotyping of mutant flies and mice, chemo- and optogenetic manipulations as well as engram labelling with viral vectors.
Teaching formats: 1 seminar (1 SWS) and 1 practical (2 SWS), both elective. All are taught in English.
Semesters offered: Every winter semester **Duration:** 1 semester
Prerequisite for participation: none
Time investment elective components: Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).

Credit points: Total number of credit points: 5 CP, elective
Examinations: Written exam 60 min (K60) or oral presentation 30 min (SV30) and one lab report. Attendance (80%) of seminars is mandatory for credit.
Module coordinators: Prof. O. Stork **Module lecturers:** Prof. O. Stork, and others
Recommended literature: Krebs, Goldstein, et al., “Genes X”, Jones & Bartlett Pubs (2009) Watson, Baker, et al., “Molecular Biology of the Gene”, Pearson (7th ed., 2013)

Degree programme: **MSc Integrative Neuroscience**
Module VA203 (5 CP elective seminars and practical work) **Neuroinflammation & CNS infections**
Module aims and learning outcomes: Having taken this elective course, students will have advanced knowledge and understanding about the immune system function and dysfunction in the central nervous system. They will learn about the newest advances in the field of neuroimmunology. **Module assessment:** The course material is assessed in the form of a written exam, to offer detailed feedback about learning performance. **Practical work:** All module components include practical lab work in addition to lectures. Working mostly independently (but under supervision) and in small groups, students acquire practical and applied skills as well as a range of broader competencies in critical analysis and synthesis of complex information ('judging') and in assuming responsibility for, and leadership of, joint research projects ('communicating').
Module component: **<u>203 Neuroinflammation & CNS infections (1 SWS seminars and 2 SWS practical work)</u>** Our course explores terminology, cells, tissues and organs of the immune system; signalling in the immune system and feedback-mechanisms; cell biology and immune function of microglia, protective immunity in the CNS, neuroinflammation and alterations of the CNS caused by pathogen microbes. In addition, the practical part of the course introduces students to infectious diseases and pathological conditions of the CNS.
Teaching formats: 1 seminars (1 SWS) and 1 practical (2 SWS), both elective. All are taught in English.
Semesters offered: Every winter semester **Duration:** 1 semester
Prerequisite for participation: none
Time investment elective components: Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).

Credit points: Total number of credit points: 5 CP, elective
Examinations: written exam 60 min (K60) or oral presentation 30 min (SV30) and one lab report. Attendance (80%) of seminars is mandatory for credit.
Module coordinators: Prof. I. Dunay **Module lecturers:** Prof. I. Dunay, and others
Recommended literature: none

Degree programme:
MSc Integrative Neuroscience

Module VA205 (5 CP elective seminars)
Networks and Behaviour

Module aims and learning outcomes:
The general aim of this course is to give the students a unique opportunity to plan and write a master thesis project proposal, including all aspects that need to be considered to conduct a high-quality scientific work in a limited time. The topic of master theses can range over different subjects, from molecular to animal and human neuroscience research. Students will be encouraged to suggest specific lecturers, in case they have already found the lab where they would like to conduct their master theses.

At the beginning of the course, the lecturers will present the projects. Subsequently, the students will meet with the lecturers 1:1 on 2-3 occasions and develop the project proposals. At the end of the course, the students prepare a 10 minute presentation and receive feedback on the project plan. Finally, the students will write a 5-page project proposal that will be evaluated. The final mark will be the average from the oral and written part.

Module assessment:
The course material is assessed in the form of a written exam or an oral presentation, to offer detailed feedback about learning performance.

Module component:
205 Networks and behaviour (3 SWS lectures, elective)
The Systems and Behavioral Neuroscience course is designed to provide students with an understanding of the techniques and approaches used to study the nervous system. Current research being conducted by lecturers in this program can be categorized into three broad topics: a) the mechanisms of sensory system development and plasticity, b) studying innate and learned behaviour by using anatomical, electrophysiological, imaging, and behavioural analysis techniques, and c) the mechanisms by which neuroendocrine hormones influence behaviour.

Teaching formats:
1 lecture (3 SWS), elective.
All taught in English.

Semesters offered:
Every winter semester
Duration:
1 semester

Prerequisite for participation:
none

Time investment elective components:
Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).

Credit points: Total number of credit points: 5 CP, elective
Examinations: written exam 60 min (K60) or oral presentation 30 min (SV30) and one lab report.
Module coordinators: Dr. S. Bauer Mikulovic **Module lecturers:** Dr. S. Bauer Mikulovic, Prof. Fred Schaper, and others.
Recommended literature: Original research literature and reviews as distributed during the course.

Degree programme: **MSc Integrative Neuroscience**
Module VA206 (5 CP elective seminars and practical work) **Quantitive Signal Transduction**
Module aims and learning outcomes: Having taken this elective course, students will have advanced knowledge and understanding of quantitative characterization of neurobiochemical signal transduction pathways. Specifically, they will be able to explain, demonstrate, and apply methods to quantitatively analyse 1) the expression of membrane-bound cytokine receptors, 2) the expression and activation of cytoplasmic transcription factors, 3) the time-dependent translocation of transcription factors into the nucleus, 4) the activation of a gene promoter and, 5) the expression of target mRNA. Additionally, key competencies such as oral and graphical communication of scientific results, presentation of complex issues, communication in groups, emotion management during oral presentations and scientific discussion, conflict management in groups and organizational management are acquired. **Module assessment:** The course material is assessed in the form of a written exam. To offer detailed feedback about the learning performance during the course each student will independently prepare and present parts of the obtained results as an oral presentation and the students will in small groups prepare a scientific protocol. - **Practical work:** All module components include practical lab work in addition to lectures. Working mostly independently (but under supervision) and in small groups, students acquire practical and applied skills in quantitative biochemical methods and cell culture of eukaryotic cells.
Module component: **<u>206 Quantitative signal transduction (1 SWS seminars, 2 SWS practical work, both elective)</u>** Students will be able to explain, demonstrate, and apply quantitative methods to analyse neurobiochemical signal transduction pathways, as well as the critical evaluation of results concerning various methodological problems. In the practical part, students monitor the activation of signalling molecules at different levels of a signal transduction cascade and employ perturbations of the input signal to elucidate the dynamics of signalling.
Teaching formats: 1 seminar (1 SWS) and 1 practical (2 SWS), both elective. All are taught in English.
Semesters offered: Every winter semester **Duration:** 1 semester

Prerequisite for participation: none
Time investment elective components: Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).
Credit points: Total number of credit points: 5 CP, elective
Examinations: written exam 60 min (K60) or oral presentation 30 min (SV30) and one lab report. Attendance (80%) of seminars is mandatory for credit.
Module coordinators: Prof. F. Schaper **Module lecturers:** Prof. F. Schaper, Dr. A. Dittrich, and others
Recommended literature: Krauss, “Biochemistry of Signal Transduction and Regulation”, Wiley-VCH (2014) Gomperts, Kramer, Tatham, “Signal Transduction”, Academic (2009) Nicholson, Nicola, eds. “JAK-STAT Signalling – Methods and Protocols”, Humana (2013)

Degree programme:
MSc Integrative Neuroscience

Module VB211 (5 CP elective seminars and practical work)
Cognitive Neurobiology

Module aims and learning outcomes:
Selected topics in cognitive neurobiology, chosen to highlight exemplary current research. Past topics have included perception and action, intermediate perception, different experimental approaches to attention, language processing, decisions, reward, emotions, executive processing, neural activity dynamics, spatial navigation, social interactions, and consciousness. In the practical part, students set up, perform, analyze, and evaluate visual psychophysical experiments using Matlab (visual 3D stimuli, decision task, sensitivity, thresholds, biases, individual differences, psychometric function fit).

Module assessment:
The course material is assessed in the form of the completed lab book for the experiments conducted in the practical. Attendance (80%) of seminars and practicals is mandatory for credit.

Practical work:
All module components include practical lab work in addition to lectures. Working mostly independently (but under supervision) and in small groups, students acquire practical and applied skills as well as a range of broader competencies in critical analysis and synthesis of complex information (‘judging’) and in assuming responsibility for, and leadership of, joint research projects (‘communicating’).

Teaching formats:
1 lecture (1 SWS) and 1 practical (2 SWS), both elective.
All are taught in English.

Semesters offered:
Every winter semester
Duration:
1 semester

Prerequisite for participation:
none

Time investment elective components:
Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).

Credit points:
Total number of credit points: 5 CP, elective

Examinations:
written exam 60 min (K60) or oral presentation 30 min (SV30) and one lab report.

Module coordinators: *Prof. K. Krug* **Module lecturers:** Prof. K. Krug, Prof. M. Sauvage, Prof. C. Lenschow, Dr. S. Bauer Mikulovic, and others
Recommended literature: Parts VI and VIII in Kandell, Koester, “Principles of Neural Science”, 6th edition (2021) Gazzaniga, Ivry, Mangun, “Cognitive Neuroscience”, 5th edition WW Norton (2019) *Purves, Brannon, et al., “Principles of Cognitive Neuroscience”, Macmillan (2013)*

Degree programme:
MSc Integrative Neuroscience

Module VB215 (5 CP elective seminars and practical)
Macroimaging

Module aims and learning outcomes:
Having completed this module, students will have advanced knowledge and understanding of structural and functional imaging approaches to the whole brain. Specifically, they will be able to recognize, organize and explain current research approaches to imaging macroscopic brain function and structure …

Modules VB215 and VB217 are complementary and, if taken together, provide a comprehensive view of imaging brain structure and activity at different levels of resolution, from the individual cell to the entire brain.

In addition, students will have acquired an overview of imaging technology and methodology together with advanced practical and applied skills in systems and behavioural neuroscience. Specifically, they will be able to explain, demonstrate, and apply different modalities of macroscopic imaging methods.

Module assessment:
The course material is assessed in the form of a written exam or an oral presentation, to offer detailed feedback about learning performance.

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Practical work:
All module components include practical lab work and demonstrations in addition to lectures. Working mostly independently (but under supervision) and in small groups, students acquire practical and applied skills as well as a range of broader competencies in critical analysis and synthesis of complex information ('judging') and in assuming responsibility for, and leadership of, joint research projects ('communicating').

Module component:
215 Macroimaging (2 SWS seminars, 1 SWS practical, both elective)
Introduction to current methods of imaging macroscopic brain structure and function. Complements 217. Physical bases and principles of magnetic resonance imaging (MRI), electroencephalography (EEG) and magnetoencephalography (MEG). Physiological basis of the hemodynamic response. Essential considerations of experimental design. Anatomical coordinate systems and their transformations. Important approaches to data analysis (general linear model). The practical part introduces students to macroscopic imaging modalities, i.e., EEG, MEG, small animal MRI, human MRI, and hands-on MRI data processing.

Teaching formats:
1 seminar (1 SWS) and 1 practical (2 SWS), both elective.
All are taught in English.

Semesters offered:
Every winter semester
Duration:
1 semester

Prerequisite for participation: none
Time investment elective components: Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).
Credit points: Total number of credit points: 5 CP, elective
Examinations: Written exam 60 min (K60) or oral presentation 30 min (SV30), with one lab report as a prerequisite. Attendance (80%) of seminars is mandatory for credit.
Module coordinators: Prof. O. Speck **Module lecturers:** Prof. O. Speck, and others
Recommended literature: Haake, Brown, et al., “Magnetic Resonance Imaging: Physical Principles and Sequence Design”, Wiley (2013)

Degree programme:
MSc Integrative Neuroscience

Module VB217 (5 CP elective seminars and practical)
Microimaging

Module aims and learning outcomes:
Having completed this module, students will have advanced knowledge and understanding of functional imaging approaches at the microscopic level. Specifically, they will be able to recognize, organize and explain current research approaches to imaging microscopic brain function.

Modules VB215 and VB217 are complementary and, if taken together, provide a comprehensive view of imaging brain activity at different levels of resolution, from the individual cell to the entire brain.

In addition, students will have acquired advanced practical and applied skills in systems and behavioural neuroscience. Specifically, they will be able to explain, demonstrate, and apply different modalities of modern microimaging techniques with state-of-the-art instrumentation.

Module assessment:
The course material is assessed in the form of a written exam or an oral presentation, to offer detailed feedback about learning performance.
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Practical work:
All module components include practical lab work in addition to lectures. Working mostly independently (but under supervision) and in small groups, students acquire practical and applied skills as well as a range of broader competencies in critical analysis and synthesis of complex information ('judging') and in assuming responsibility for, and leadership of, joint research projects ('communicating').

Module component:
217 Microimaging (1 SWS seminars, 2 SWS practical, both elective)
Introduction to current methods of imaging microscopic brain activity at the cellular, sub-cellular, and molecular levels. Complements 215. Wide field, fluorescence, confocal, 2-photon, and STED microscopy, fluorescent and photoreactive agents, ion- and voltage-dependent dyes, FRET, FRAP, photoactive ligands and chelators. The practical part focuses on a combination of electrophysiological, cell functional, and morphological analysis by applying modern microimaging techniques with state-of-the-art instrumentation.

Teaching formats:
1 lecture (1 SWS) and 1 practical (2 SWS), both elective.
All are taught in English.

Semesters offered:
Every winter semester
Duration:
1 semester

Prerequisite for participation: none
Time investment elective components: Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).
Credit points: Total number of credit points: 5 CP, elective
Examinations: written exam 60 min (K60) or oral presentation 30 min (SV30) and one lab report as a prerequisite. Attendance (80%) of seminars is mandatory for credit.
Module coordinators: Dr. H. Jia **Module lecturers:** Dr. H. Jia, and others.
Recommended literature: Cox, “Optical Imaging Techniques in Cell Biology”, CRC Press, 2012. Pawley, Handbook of Biological Confocal Microscopy, Springer, 2006. Valeur, “Molecular Fluorescence: Principles and Applications”, Wiley-VCH, 2012. Sauer, Hofkens, Enderlein, “Handbook of Fluorescence Spectroscopy and Imaging”, Wiley-VCH, 2011.

Degree programme:
MSc Integrative Neuroscience

Module VC223 (5 CP elective seminars and practical)
Virtual Reality for Neuroscience and Psychology

Module aims and learning outcomes:
Having completed this module, students will have advanced knowledge and understanding of virtual reality techniques for neuroscience and psychology. Specifically, they will be able to recognise, organise and explain current research approaches in the field.

In addition, students will have acquired advanced practical and applied skills in systems and behavioural neuroscience. Specifically, they will be able to explain, demonstrate, and apply different modalities of virtual reality across species.

Module assessment:
The course material is assessed in different ways, chosen to provide helpful feedback about learning performance, in the judgment of the responsible lecturers. As students may elect to participate in any combination of module components, each component is assessed separately.

Practical work:
The module component includes both lectures and practical work. Working mostly independently (but under supervision) and in small groups, students acquire practical and applied skills as well as a range of broader competencies in critical analysis and synthesis of complex information (‘judging’) and in assuming responsibility for and leadership of, joint research projects (‘communicating’). The practical work will also include statistical analyses of experimental datasets gathered during the course.

Module component:
223 Virtual Reality for Neuroscience and Psychology (2 SWS seminars, 1 SWS practical work, both elective)
Virtual reality (VR) and related technologies (Augmented / Mixed Reality) are powerful tools for understanding the human mind. In addition, virtual reality is thought to have the potential to revolutionize healthcare for both mental and sensorimotor disorders. This course will introduce the latest developments in virtual reality technology and its key applications for psychological and neuroscience research. We will discuss what makes VR such a powerful technology and demonstrate how it is used – across species – to understand fundamental principles of neural and behavioural processing. In the second half of the course, we will explore the clinical potential of VR, for example, applications for treating mental and sensorimotor disorders.

Teaching formats:
1 seminar (1 SWS) and 1 practical (2 SWS), both elective.
All are taught in English.

Semesters offered:
Every winter semester
Duration:
1 semester

Prerequisite for participation:
none

Time investment elective components:
Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).

Credit points:
Total number of credit points: 5 CP, elective

Examinations:
written exam 60 min (K60) or oral presentation 30 min (SV30) and one lab report as a prerequisite.
Attendance (80%) of seminars is mandatory for credit.

Module coordinators:
Prof. T. Wolbers

Module lecturers:
Prof. T. Wolbers, Dr. J. Pakan, and others

Recommended literature:
Jerald J (2015). The VR Book: Human-Centered Design for Virtual Reality. ACM Books.

Diersch N, Wolbers T (2019) The potential of virtual reality for spatial navigation research across the adult lifespan. J Exp Biol 222:jeb187252.

Emmelkamp PMG, Meyerbröker K. (2021). Virtual Reality Therapy in Mental Health. Annu Rev Clin Psychol; 17:495-519.

Stowers, J., Hofbauer, M., Bastien, R. et al. Virtual reality for freely moving animals. Nat Methods 14, 995–1002 (2017).

Degree programme: **MSc Integrative Neuroscience**
Module VD241 (5 CP elective seminars) **Clinical Neuroscience**
Module aims and learning outcomes: Having completed this module, students will have advanced knowledge and understanding in clinical and/or applied neuroscience. Specifically, they will be able to recognize, organize and explain the systematic aetiology of psychiatric and neurological (including genetic, developmental, traumatic, organic, metabolic and endogenous causes). **Module assessment:** The course material is assessed in the form of a written exam or an oral presentation, in order to offer detailed feedback about learning performance.
Module component: **<u>241 Clinical neuroscience (3 SWS seminars, elective)</u>** Introduction to clinical neuroscience, including presentation of suitable clinical case examples. History of psychiatry, humanistic and scientific approaches, tetradic system, inherited factors, early traumas, late traumas, brain lesions, disorders of brain development, psychiatric disorders, ICD-100 system, endogenous psychoses, psychogenic disorders, individual variability of normals. And basic knowledge of neurological conditions. Stroke, movement disorders, epilepsy. Psychopharmacology: Neurobiological foundations and clinical effects.
Teaching formats: 1 seminar (3 SWS), elective. All are taught in English.
Semesters offered: Every winter semester **Duration:** 1 semester
Prerequisite for participation: none
Time investment elective components: Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).

Credit points: Total number of credit points: 5 CP, elective
Examinations: written exam 60 min (K60) or oral presentation 30 min (SV30) and one lab report as a prerequisite. Attendance (80%) of seminars is mandatory for credit.
Module coordinators: Dr. A. Maaß, Prof. M. Walter **Module lecturers:** Dr. A. Maaß, Prof. M. Walter, and others
Recommended literature: Charney, Nestler, eds., “Neurobiology of Mental Illness.” Oxford UP (2011)

Degree programme: **MSc Integrative Neuroscience**
Module VD243 (5 CP elective seminars and practical) **Behavioural Pharmacology**
Module aims and learning outcomes: Having completed this module, students will have advanced knowledge and understanding in clinical and/or applied neuroscience with a focus on pharmacological aspects. Specifically, they will be able to explain, plan and conduct neuropharmacological experiments. **Module assessment:** The course material is assessed in the form of short essays about selected seminars, in order to offer detailed feedback about learning performance and the understanding of the key concepts of behavioural pharmacology. **Practical work:** One module component includes practical work in addition to a lecture. Working mostly independently (but under supervision) and in small groups, students acquire practical and applied skills as well as a range of broader competencies in critical analysis and synthesis of complex information ('judging') and in assuming responsibility for, and leadership of, joint research projects ('communicating').
Module component: **243 Behavioural Pharmacology (2 SWS seminars, 1 SWS practical work, both elective)** The course gives an introduction to pharmacological determinants of brain function and behaviour and an overview of drug-induced changes in the functioning of the nervous system. The role and interaction of transmitter systems, neuromodulators and hormones related to brain function are discussed. Major topics cover basic principles of behavioural pharmacology as well as specific aspects of the pharmacology of learning and memory, emotional behaviour, neuronal plasticity, stress and addiction. The lectures include neuroanatomical (brain regions and cell populations), neurophysiological (activity, plasticity, intracellular signals), molecular (genetic and proteomic functions) and neuropathological aspects. The practical course introduces students to neuropharmacological experiments. Changes in different behavioural parameters (i.e. motoric, emotional, cognitive) after drug application will be analyzed.
Teaching formats: 1 seminar (1 SWS) and 1 practical (2 SWS), both elective. All are taught in English.
Semesters offered: Every winter semester **Duration:** 1 semester

Prerequisite for participation: none
Time investment elective components: Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).
Credit points: Total number of credit points: 5 CP, elective
Examinations: written exam 60 min (K60) or oral presentation 30 min (SV30) and one lab report as a prerequisite. Attendance (80%) of seminars is mandatory for credit.
Module coordinators: apl. Prof. J. Bock **Module lecturers:** apl. Prof. J. Bock, Prof. M. Fendt, and others
Recommended literature: Nestler, Hyman & Malenka, “Molecular Neuropharmacology”, McGrawHill Medical (2008).

Degree programme: **MSc Integrative Neuroscience**
Module VD245 (5 CP seminars, elective) **Cognitive Neuroimaging**
Module aims and learning outcomes: After completing this module, students will have advanced knowledge and understanding in cognitive neuroimaging. Specifically, they will be able to recognize, organize, and explain how brain activity may be measured and modulated in different cognitive domains. **Module assessment:** The course material is assessed in the form of a written exam or an oral presentation, in order to offer detailed feedback about learning performance.
Module component: **<u>245 Cognitive neuroimaging (3 SWS lecture, elective)</u>** Introduction to human cognitive neuroimaging techniques. The course provides an overview of a range of brain signal recording modalities applied in basic neuroscience as well as in the clinical setting. Insights provided into motor learning and also higher cognitive functions such as memory processing are explored. Interventions based on cognitive neuroimaging data are considered, including non-invasive brain stimulation, deep brain stimulation, and brain-computer interfaces.
Teaching formats: 1 seminars (3 SWS), elective. All are taught in English.
Semesters offered: Every winter semester **Duration:** 1 semester
Prerequisite for participation: none
Time investment elective components: Face-to-face: 42h (=3 SWS). Independent study: 108h. Total: 150h (=5 CP).
Credit points: Total number of credit points: 5 CP, elective
Examinations: written exam 60 min (K60) or oral presentation 30 min (SV30). Attendance (80%) of seminars is mandatory for credit.

Module coordinators:
Dr. C. Sweeney-Reed

Module lecturers:
Dr. C. Sweeney-Reed, and others.

Recommended literature:
Lazar, “The Statistical Analysis of functional MRI Data”, Springer (2008)
Faro, Mohammed “Functional MRI: Basic Principles and Clinical Applications”, Springer (2012)
Faro, Mohammed “Bold fMRI: A Guide to Functional Imaging for Neuroscientists”, Springer (2010)

Degree programme:
MSc Integrative Neuroscience

Module GX/VX (15 CP obligatory, 16 CP elective)
Professional Skills

Module aims and learning outcomes:
By participating in the courses of this module, students develop practical and applied skills in neuroscientific research methods as well as a broad range of professional key competences in judging, learning, and communicating (in the sense of the European Qualification Framework). Three *lab rotations* provide first-hand experience in conducting neuroscience research and in communicating its results in written and oral form. *Neuroethology* offers exemplary glimpses of particularly original and successful research projects rather than foundational knowledge and understanding**.** *Philosophy and ethics of science* provide experience in judging and resolving complex situations characterized by conflicting values and interests. *Scientific writing* provides extensive coaching in structuring, composing, and persuading with a scientific text. *Journal club* and *Neurocolloquium* provide further practice in structuring, communicating, and judging complex scientific materials and in professional communication.

All components of this module focus on independent and practical work. Working independently or in small groups, students acquire practical and applied skills as well as a range of broader competencies. Specifically they acquire

'competence in judging' – i.e., the ability to integrate and structure complex neuroscientific information, to identify and justify key aspects of a neuroscientific research question, to compare and choose between alternative paths of action, and to formulate and justify judgments on the basis of preliminary information

'competence in learning' – i.e., the ability to structure one's learning process, to deepen and enlarge one's knowledge, to integrate newly acquired information with prior knowledge, to apply newly acquired information, to rate correctly one's knowledge level, to identify and to consult additional sources of information, and to request further assistance or study materials

and

'competence in communicating' – i.e., the ability to communicate facts, conclusions, and rationales to specialist and non-specialist audiences, to respond constructively to scientific, cultural, or ethical issues arising in the context of group work (such as to re-negotiate roles and to resolve conflicts), and to assume the responsibility for, and leadership of, joint research projects.

Module assessment:
The course material is assessed in different ways, chosen to provide helpful feedback about learning performance, in the judgment of the responsible lecturers. All module components are assessed separately.

Module components:

109S Neuroethology (2 SWS seminars, obligatory)

Selected animals and behaviours, varying from year to year, in which the neurobiological basis of behaviour is particularly well studied and understood. These "highlights" are presented in order to emphasize the advantages (and difficulties) of the integrative approach to neuroscience. Past topics have included electroreception in fish, auditory localization in owls, echo localization in bats or dolphins, communication in penguins, navigation in rats, visual perceptual and recognition in pigeons, physical and social cognition in primates, theory of mind in primates, among others. Features invited lecturers from other leading research institutions.

119L Philosophy of Computation and Neurocognition (2 SWS lectures, obligatory)

Covers the methods, foundations, and conclusions of science and topics of scientific ethics. Includes induction, hypothetic and falsification, deduction and statistical explanation, laws of nature and causality, syntactic vs. semantic views of theories, theory-ladenness of observation, theory underdetermination, confirmational holism, theory reduction, scientific realism, instrumentalism, constructivism, empiricism, structural realism, ethics of science, ethics of research, standards of scientific conduct. Learning progress is assessed in three written exams (3x K20).

290T Scientific writing (2 SWS tutorials, obligatory)

Currently taught by an experienced tutor who is both a native English speaker and a former neuroscientist. Three full-day tutorials including a half-day writing assignment assessed by the tutor. Covers composition as a process, the structure of research papers, common language pitfalls for non-native speakers/writers of academic English, paragraph structure, academic style, sentence structure, revision strategies and reader awareness.

190 Lab rotations I, II, and III (9 SWS practical work, obligatory)

„Lab rotations" are an essential part of the study programme. All students carry out three lab rotations over the first three semesters. Each lab rotation consists of a practical research project of (at least) four weeks duration, a written report, and a public seminar presentation. Both report and presentation are expected to meet the highest professional standards. Lab rotations expose students to different topics and methods of neuroscience research and helps them find a suitable laboratory for their Master's thesis. All research groups and Institutes participating in the MSc Integrative Neuroscience programme may supervise lab rotations.

117L Introduction to Matlab (2 SWS seminars, optional)

Introduction to scientific programming in the Matlab environment for students with little or no prior programming experience.

180 Journal club (2 SWS seminars, optional)

Journal clubs on specific areas of integrative neuroscience, each organized and supervised by a lecturer. Involves weekly readings of current publications of interest and students presenting a brief summary and appreciation of these publications.

185 Neurocolloquium (2 SWS seminars, optional) Regular research seminars of research institutes, ‘Sonderforschungsbereiche’, ‘Forschungsverbünde’, and the Leibniz Institute of Neurobiology.
Teaching formats: 109: obligatory seminar (2 SWS) 119: obligatory lecture (2 SWS) 290: obligatory tutorial (2 SWS) 190: three obligatory practical courses (3 SWS) 117: optional tutorial (2 SWS) 180, 185: optional seminars (2 SWS each) All taught in English.
Semesters offered: 109, 290 every winter semester 117, 119 every summer semester 180, 185, 190 every semester **Duration:** 1 semester
Prerequisite for participation: none
Time investment core components: Face-to-face: 210h (=15 SWS). Independent study: 240h. Total: 450h (=15 CP). **Time investment elective components:** Face-to-face: 56h (=4 SWS). Independent study: 64h. Total: 120h (=4 CP).

Credit points:
Total number of credit points: 15 CP obligatory, 16 CP elective
109: obligatory seminar (2 CP)
119: obligatory lecture (2 CP)
290: obligatory tutorial (2 CP)
190: three obligatory practical courses (3 CP each)
117: optional tutorial (2 CP)
180, 185: optional seminars (2 CP each)

Assessment and Examinations:
109: one homework assignment (EB). Attendance (80%) of seminars is mandatory for credit.
119: three written exams (3xK20)
290: homework assignments (HA), attendance (80%) of tutorials is mandatory for credit.
190: written lab report and oral presentation 30 min (SV30).
117: attendance (80%) of tutorials is mandatory for credit.
180: oral presentation 30 min (SV30), attendance (80%) of seminars is mandatory for credit.
185: attendance (80%) of seminars is mandatory for credit.

Module coordinators:
Lecturers of IBIO

Module lecturers:
Lecturers of other modules

Recommended literature:
119*:* Weiss, "The Elements of International English Style", ME Sharpe (2005)
Katz, "From Research to Manuscript: A Guide to Scientific Writing", Springer Netherlands (2008)

290*:* Bird, "Philosophy of Science", Routledge (1998)
Godfrey-Smith, "Theory and Reality: An Introduction to the Philosophy of Science", UChicago Press (2003).
Hacking, "An Introduction to Probability and Inductive Logic", Cambridge UP (2001)
Resnik, "The Ethics of Science: An Introduction", Routledge (1998).

Legend:

CP = Number of Credit Points
EB = Individual written report (e.g., lab or project report)
HA = homework assignment
K120 = written exam of 120 min duration
K60 = written exam of 60 min duration
K20 = written exam of 20 min duration
SV30 = seminar presentation of 30 min duration

Definition of learning outcomes

The learning outcomes of the degree programme are formulated in terms of the ‘Dublin descriptors’ of the European Higher Education Area and of the European Qualifications Framework (EQF). In defining the learning outcomes of the Master’s programme, it is helpful to compare and contrast the typical learning outcomes of doctoral programmes:

‘Knowledge and understanding’

A systematic understanding of a particular area of neuroscience and a broad foundation for conceiving and implementing original ideas, scientific concepts and solutions for research problems in this area. This requires the ability to recognize, organize, and explain current knowledge in an area of neuroscience and to explain and demonstrate current methods and approaches in this research area. It is to be distinguished from an established track record of conceiving and implementing original ideas and solutions, which is typically demonstrated during doctoral studies.

‘Practical and applied skills’

A partial mastery of the research methods of particular areas of neuroscience and an ability to solve largely independently research problems in new or unfamiliar settings and in broadly multi-disciplinary contexts. This includes an ability to extend the current state of knowledge in a limited way that may nevertheless merit international refereed publication. It is to be distinguished from a full mastery of research methods and an ability to fully independently extend current knowledge in a substantial way meriting multiple international refereed publications, which are typically attained during doctoral studies.

‘Broader competence in judging’

A capability for critical analysis and synthesis of complex information about a circumscribed research area. In particular, the ability to integrate and structure complex neuroscientific information, to identify and justify key aspects of a neuroscientific research question, to compare and choose between alternative paths of action, and to formulate and justify judgements based on partial or preliminary information. To be contrasted with the capability for critical analysis and synthesis of complex information about an open-ended research area, which is typical of doctoral studies.

‘Broader competence in learning’

A largely independent capability to structure one’s learning process, deepen and enlarge one’s knowledge, integrate newly acquired information with prior knowledge, and apply newly acquired information to a circumscribed research area. Also includes an ability to rate correctly one’s knowledge level, to identify and consult additional sources of information, and to request further assistance or study materials. To be distinguished from the ability, typically attained after doctoral studies, to fully autonomously advance one’s scholarly knowledge in an open-ended research area.

‘Broader competence in communicating’

An ability to communicate in written, graphical and spoken form, both in scholarly and informal settings. In particular, an ability to communicate facts, conclusions, and rationales of restricted scope to specialist and non-specialist audiences (monologue). Includes an ability to respond constructively to scientific, cultural, or ethical issues arising in the context of group work (such as to re-negotiate roles and resolve conflicts). Further includes an ability to assume the responsibility for, and leadership of, joint research projects in circumscribed research areas. To be distinguished from the ability, typically attained after doctoral studies, to maintain a dialogue about one’s area of expertise (broad scope) with the scholarly community and society at large.

‘Broader competence in communicating’

An ability to communicate in written, graphical and spoken form, both in scholarly and in informal settings. In particular, an ability to communicate facts, conclusions, and rationales of restricted scope to specialist and non-specialist audiences (monologue). Includes an ability to respond constructively to scientific, cultural, or ethical issues arising in the context of group work (such as to re-negotiate roles and to resolve conflicts). Further includes an ability to assume the responsibility for, and leadership of, joint research projects in circumscribed research areas. To be distinguished from the ability, typically attained after doctoral studies, to maintain a dialogue about one’s area of expertise (broad scope) with the scholarly community and society at large.

Anlage

Regelstudienplan und Prüfungsplan des Masterstudiengangs *Integrative Neuroscience*

Pflichtfächer

			CP							Prüfungsplan		
	Module	***PM WPM***	***WS*** 1. Sem.	***SS*** 2. Sem.	***WS*** 3. Sem.	***SS*** 4. Sem.	***Vorlesung/ Seminar***	***Übung***	***Praktikum***	*CP*	*LN*	*PL*
1. Semester	Kleines Wahlpflichtmodul (unbenotet)*	WPM	2							2		
	101 Cellular Neurophysiology	PM	5				2 SWS		2 SWS	5	x	K120
	102 Basic Molecular & Cell Biology	PM	5				3 SWS		2 SWS	5	x	K120
	103 Integrative & Comparative Neuroanatomy	PM	5				3 SWS		2 SWS	5	x	K120
	105 Theoretical Neuroscience I (Neurons)	PM	5				3 SWS	2 SWS		5	x	K120
	106/116 Mathematical Foundations	PM	3				2 SWS	2 SWS		3	x	K120
	109 Neuroethology	PM	2				2 SWS			2		HA+EA
	190 Lab Rotation I	PM	3				3 SWS			3		EA+SV30
2. Semester	Kleines Wahlpflichtmodul (unbenotet)*	WPM		2						2		
	111 Molecular & Cellular Neurobiology	PM		5			2 SWS		2 SWS	5	x	K120
	113 Systems Neurophysiology	PM		5			3 SWS		2 SWS	5	x	K120
	112/114 Development & Learning	PM		5			5 SWS			5		K120+EB
	115 Theoretical Neuroscience II (Networks)	PM		5			3 SWS	2 SWS		5	x	K120
	106/116 Advanced Statistics for Neuroscience	PM		3			2 SWS	2 SWS		3	x	K120
	119 Philosophy of Computation and Neurocognition	PM		2			2 SWS			2		3xK20
	190 Lab Rotation II	PM		3			3 SWS			3		EA+SV30
3. Semester	fünf große Wahlpflichtmodule*	WPM			25					25		
	290 Scientific Writing	PM			2		2 SWS			2		HA+GA
	190 Lab Rotation III	PM			3		3 SWS			3		EA+SV30
4. Se-mes-ter	Master Arbeit mit Kolloquium	PM				30				30		
	Summe CP:		**30**	**30**	**30**	**30**				**120**		

*** Wahlpflichtmodule sind aus dem jeweils gültigen Modulhandbuch auszuwählen.**

Legende zum Regelstudienplan und Prüfungsplan

WS Wintersemester	WPM Wahlpflichtmodul	PL Prüfungsleistung	K Klausur	SV Seminarvortrag
SS Sommersemester	SWS Semesterwochenstunden	LN Prüfungsvorleistung	HA Hausarbeit	GA Gruppenarbeit
PM Pflichtmodul	CP Credit Points	x erforderlich	EA experimentelle Arbeit	

Regelstudienplan und Prüfungsplan des Masterstudiengangs *Integrative Neuroscience*

Wahlpflichtfächer

		Module	CP WS	CP SS	Vorlesung/ Seminar	Übung	Praktikum	Prüfungsplan CP	Prüfungsplan LN	Prüfungsplan PL
Angebot WS	kleines WPF	101 Cellular Neurophysiology (Übung unbenotet)	2			1 SWS		2		GA
		102 Basic Molecular and Cell Biology (Übung unbenotet)	2			1 SWS		2		GA
		103 Integrative and Comparative Neuroanatomy (Übung unbenotet)	2			1 SWS		2		GA
	großes WPF	201 Genetic Models	5		1 SWS		2 SWS	5	x	K60/SV30
		203 Neuroinflammation and CNS Infections	5		1 SWS		2 SWS	5	x	K60/SV30
		205 Networks and Behaviour	5		3 SWS			5		K60/SV30
		206 Quantitative Signal Transduction	5		1 SWS		2 SWS	5	x	K60/SV30
		211 Cognitive Neurobiology	5		2 SWS		1 SWS	5	x	K60/SV30
		215 Macroimaging	5		2 SWS		1 SWS	5	x	K60/SV30
		217 Microimaging	5		2 SWS		1 SWS	5	x	K60/SV30
		223 Virtual Reality for Neuroscience and Psychology	5		2 SWS		1 SWS	5	x	K60/SV30
		241 Clinical Neuroscience	5		3 SWS			5		K60/SV30
		243 Behavioural Pharmacology	5		2 SWS		1 SWS	5	x	K60/SV30
		245 Cognitive Neurobiology	5		3 SWS			5		K60/SV30
Angebot SS	kleines WPF	111 Molecular and Cellular Neurobiology (Übung unbenotet)		2		2 SWS		2		GA
		112 Development and Plasticity (Übung unbenotet)		2		2 SWS		2		GA
		Summe CP:	**61**	**4**				**65**		

Legende zum Regelstudienplan und Prüfungsplan

WS Wintersemester	WPM Wahlpflichtmodul	PL Prüfungsleistung	K Klausur	SV Seminarvortrag
SS Sommersemester	SWS Semesterwochenstunden	LN Prüfungsvorleistung	HA Hausarbeit	GA Gruppenarbeit
PM Pflichtmodul	CP Credit Points	x erforderlich	EA experimentelle Arbeit	

Regelstudienplan und Prüfungsplan des Masterstudiengangs *Integrative Neuroscience*

Wahlfächer

	Module	CP WS	CP SS	Vorlesung/ Seminar	Übung	Praktikum	Prüfungsplan CP	Prüfungsplan LN	Prüfungsplan PL
Angebot WS/SS	117 Introduction to Matlab		2	2 SWS			2		GA
	180 Journal Club	2	2	2 SWS			2		SV30
	185 Neurocolloquium	1	1	2 SWS			1		
	Summe CP:	**3**	**5**				**5**		

Legende zum Regelstudienplan und Prüfungsplan

WS Wintersemester
SS Sommersemester
PM Pflichtmodul

WPM Wahlpflichtmodul
SWS Semesterwochenstunden
CP Credit Points

PL Prüfungsleistung
LN Prüfungsvorleistung
x erforderlich

K Klausur
HW Hausaufgaben
EB Einzelbericht

SV Seminarvortrag
GA Gruppenarbeit