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 40 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 competences.

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 (32CP) 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 (28CP), students participate in the ongoing work of one of the research institutes and take part in their research seminars (2 SWS).

Knowledge, skills and competences

In addition to specific knowledge and skills in neuroscience, all parts of the course programme also teach broader competences (‘key competences’) such as making independent judgements, learning in a self-directed manner, and communicating to scientific and general audiences. Courses that specifically concern key competences are combined into Module X "Professional key competences" (20-25 CP). In addition, many integral components of other courses – such as practical courses, tutorials, seminars, homework assignments, seminar presentations – contribute also to the acquisition of broader competences. These integral components comprise 12-24 CP obligatory practical work, 12 CP elective practical work, and 18 CP elective tutorials.

In summary, approximately 43% of the credits concern neuroscientific knowledge and understanding, approximately 17% concern a combination of neuroscientific skills and key competences, approximately 17% are dedicated specifically to key competences, und approximately 23% to the master thesis.

Knowledge and skills in neuroscience	52 Credits	(43%)
Key competences (integrated in other courses)	20-32 Credits	(17%)
Key competences (in dedicated courses)	20-25 Credits	(17%)
Master thesis	28 Credits	(23%)

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
- Prerequisites for participation
- Time investment (face-to-face and independent study)
- Credit points
- Assessment and examinations
- Module coordinators and module lecturers
- Recommended literature

Contents

Degree programme: **MSc Integrative Neuroscience**
Module GA1 (9 CP obligatory und 2 CP elective): **Fundamental molecular and cellular neuroscience I**
Module aims and learning outcomes: At the end of the module, students will have a fundamental knowledge and understanding in molecular and cell biology and in cellular neurophysiology. Specifically, they will be able to recognize, organize and explain the molecular components and cellular organelles or neurones and glia, the major metabolic and 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 molecular and cell biology and in cellular neurophysiology. Specifically, they will be able to explain, demonstrate, and apply biochemical analysis reagents, molecular cloning techniques, electronic recording equipment, and extracellular recording from hippocampal slice preparations. Furthermore, in performing the laboratory experiments and preparing a professional report, students will have acquired broader competences in judging complex information, learning independently, and communicating in a scholarly context. **Module assessment:** The course material is assessed in the form of two written exams and two lab reports, in order to offer detailed feedback about learning performance. On the basis of this feedback, students can identify and remedy any deficiencies before progressing to module GA2. To avoid penalizing students with a weaker background in this area, students may choose to have one assessment recorded as pass/fail. **Elective tutorials:** Students with a weaker background in biochemistry and cell biology are encouraged to attend the elective tutorials. They offer and opportunity for further discussion of and additional questions about the lecture materials.
Module components: **<u>101 Cellular neurophysiology (2 SWS lecture, 2 SWS practical, 1 SWS tutorial as elective)</u>** Cellular mechanisms of the electrical excitability of nerve cells and the transmission of excitation and of information between nerve cells. Axonal and synaptic transmission of excitation, neurotransmitters, neuromodulators, 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, alternative possibilities of information storage, plasticity of synapses, pathophysioloy of nerve cells, and modern methods of neurophysiology.

The practical consists of an introduction to 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.

102 Basic molecular and cell biology (3 SWS lecture, 1 SWS practical, 1 SWS tutorial as elective)

Foundations of general molecular and cell biology, *not* pertaining specifically to neurons, 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.

The practical provides an introduction to good laboratory praxis and to laboratory safety issues. Experiments performed include the making of buffers and dilutions, colorimetric determination of protein concentration and the handling, transformation and growth of bacteria. An introduction is given how to write a protocol.

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 organic chemistry and biochemistry.

Teaching formats:
2 obligatory lectures (3 SWS and 2 SWS)
2 obligatory practicals (2 SWS and 1 SWS)
2 elective tutorials (1 SWS each).
All taught in English.

Semesters offered:
Every WS
Duration:
1 semester

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

Time investment core components:
Face-to-face: 112h (=8 SWS). Independent study: 158h. Total: 270h (=9 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: 9 CP obligatory plus 2 CP elective

101: 3 CP lecture, 2 CP practical, plus 1 CP tutorial (elective)

102: 3 CP lecture, 1 CP practical, plus 1 CP tutorial (elective)

Assessment and examinations:

Mastery of course materials is assessed in written examinations (K120) for lectures and in a lab report (EB) for practicals. Tutorials are not assessed. All assessments are graded, but students may choose to have one assessment recorded as pass/fail. The final module grade is the CP-weighted average of all graded assessments (written examinations and lab reports).

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

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

Module coordinators:

Dr. Oliver Stork, Prof. G. Reiser.

Module lecturers:

PD D. Dieterich, Prof. E. Gundelfinger, Prof. V Leßmann, PD C. Seidenbecher, Prof. G. Reiser, Prof. O. Stork, Prof. T. Voigt, Prof. F. Schaper, Dr. W. Altrock, PD Dr. P. Heil, Dr. T. Munsch, Dr. M. Heine 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)

Lehninger, "Principles of Biochemistry", W.H. Freeman (2008, 2012)

Lodish, Berk,et al., "Molecular Cell Biology". W. H. Freeman (2012)

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.

Degree programme:
MSc Integrative Neuroscience

Module GA2 (8 CP obligatory and 4 CP elective):
Fundamental molecular and cellular neuroscience II

Module aims and learning outcomes:
At the end of the module, students will have comprehensive and fundamental knowledge and understanding in 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, 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'). 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. Furthermore, in performing the laboratory experiments and preparing a professional report, students will have acquired broader competences in judging complex information, learning independently and communicating in a scholarly context.

Module assessment:
The course material is assessed in the form of two written exams and one lab report, in order to offer detailed feedback about learning performance. On the basis of this feedback, students can identify and remedy any deficiencies before progressing to module VA and VD. To avoid penalizing students with a weaker background in this area, students may choose to have one assessment recorded as pass/fail.

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

Module components:
111 Molecular and cellular neurobiology (2 SWS lecture, 2 SWS practical course, 2 SWS tutorial as elective)
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, diagnostic applications.

In the practical course, students apply important methods such as molecular cloning, biochemistry of proteins, Southern, Northern, und Western Blotting, and polymerase chain reactions.

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 molecular and cell biology.

112 Development and plasticity (2 SWS lecture, 2 SWS tutorial as elective)

Development of the vertebrate brain and mechanism of forming, pruning, and reorganizing synaptic connectivity. Differentiation of the neural tube, inductive signals, neuronal identity (stem cells) and differentiation, cell proliferation and cell death, cell migration, axon growth and pathfinding, synaptogenesis, developmental and epigenetically regulated synaptic plasticity, microanatomical, cellular and molecular bases of synaptic plasticity in vivo and in vitro, neurodevelopmental disorders.

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.

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

Semesters offered:
Every SS
Duration:
1 semester

Prerequisites for participation:
Completion of module GA1.

Time investment core components:
Face-to-face: 84h (=6 SWS). Independent study: 156h. Total: 240h (=8 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: 8 CP obligatory plus 4 CP elective
111: 3 CP lecture, 2 CP practical course, plus 2 CP tutorial (elective)
112: 3 CP lecture, plus 2 CP tutorial (elective)

Assessment and examinations:
Mastery of course materials is assessed in written examinations (K120) for lectures and in a lab report (EB) for practical courses. Tutorials are not assessed. All assessments are graded, but students may choose to have one assessment recorded as pass/fail. The final module grade is the CP-weighted average of all graded assessments (written examinations and lab reports).
111 lecture: written exam 120 min (K120); *111 practical course:* lab report (EB)
112 lecture: written exam 120 min (K120).

Module coordinators:
Prof. K. Braun, Prof. O. Stork
Module lecturers:
PD J. Bock, Prof. K. Braun, Prof. E. Gundelfinger, Prof. V Leßmann, Prof. G. Reiser, PD C. Seidenbecher, Prof. O. Stork, Dr. M. Heine, Dr. U. Thomas, Dr. T. Munsch and others.

Recommended literature:
111:
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)
112:
Squire, Berg, et al., “Fundamental Neuroscience”, Academic Press, (2012).
Parts VII in Kandell, Schwartz, Jessell, “Principles of Neural Science” (2012)
Unit IV in Purves, Augustine, et al., eds., “Neuroscience” (2011)
Sanes, Reh, Harris, “Development of the Nervous System”, Academic Press (2011)
Price, Jarman, et al., “Building Brains: an Introduction to Neural Development” (2011)

Degree programme:
MSc Integrative Neuroscience

Module GB (15 CP obligatory and 2 CP elective):
Fundamental systems and behavioural neuroscience

Module aims and learning outcomes:
At the end of the module, students will have comprehensive and fundamental knowledge and understanding in systems and behavioural neuroscience. Specifically, they will be able to recognize, organize and explain modern neuroanatomical, neurophysiological and behavioural approaches in neuroscience research, as well as the particular advantages and challenges of integrative approaches to the neurobiological bases of behaviour. They will be able to recognize, organize and explain vertebrate neuroanatomy and functional brain systems in considerable detail (especially limbic, visual, auditory, somatosensory and motor systems). With respect to learning and memory systems, they will be able to recognize, organize and explain the various systems defined by animal and human research paradigms, and will have experienced the difficulty of integrating these disparate research traditions. In addition, students will have acquired further practical and applied skills in neurohistology, neuronanatomy and single-unit neurophysiology. Specifically, they will be able to explain, demonstrate and apply extra- and intracellular single-unit and/or patch clamp recording techniques as well as various microscopic techniques of neurohistology. Furthermore, in performing the laboratory experiments and preparing a professional report, students will have acquired broader competences in judging complex information, learning independently and communicating in a scholarly context.

Module assessment:
The course material is assessed in the form of two written exams and two lab reports, in order to offer detailed feedback about learning performance. On the basis of this feedback, students can identify and remedy any deficiencies before progressing to module VB and VD. Due to the comparatively small number of assessments, all are recorded as graded.

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

Module components:
<u>103 Comparative and integrative neuroanatomy (3 SWS lecture, 1 SWS practical, 2 SWS tutorial as elective)</u>
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 vertebrates, gross and detailed human neuroanatomy (spinal cord, myelencephalon, rhombencephalon, mesencephalon, diencephalon, telencephalon, cranial and spinal nerves, transmitters systems) and functional systems (vegetative/autonomic, motoric, limbic, sensory and executive).

In the practical course, students become familiar with the histology of nervous tissues by performing microscopic work with brain preparations from different vertebrate groups.

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 histology and anatomy.

104 Neuroethology (2 SWS lecture)
Selected animals and behaviours, varying from year to year, 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, echolocalization 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.

113 Systems neurophysiology (3 SWS lecture, 2 SWS practical)
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. Specific topics include cell types and circuits in neocortex and archicortex of primates, cortical areas, connectivity and hierarchies. In depth treatment of 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, striatum and cerebellum).

The practical course is currently offered in three versions, some of which are also offered twice. Each practical course accommodates a maximum of 6 students.

A: Methods of systems neurophysiology, Prof. Ohl (one week)
Students perform extracellular recordings of single neurons and current-source density analysis, in the inferior colliculus and the auditor cortex of gerbils.

B: Synaptic and behavioural plasticity, PD Korz (one week)
Stimulation and extracellular recordings in intact and freely behaving animals. Chronic implantation of electrodes into the hippocampal dentate gyrus, CA1 and CA3 as well as perforant path in rats. Induction and recording of long-term potentiation (LTP) during spatial training. Effects of spatial learning and memory formation on the maintenance of LTP.

C: Electrophysiology methods, Dr. Munch and PD Heine (two weeks)
Intracellular and extracellular recordings of neuronal activity in invertebrates (drosophila/lymnea) and in vertebrate brain slices (mouse), as well as patch-clamp recordings from cultured neurons.

<u>**114 Learning and memory (3 SWS lecture)**</u>

The neurobiological basis of learning and memory is taught in a separate course, due to the particular strength of local research on these topics. This advanced course compares animal and human paradigms in the study of learning memory and takes an in-depth look at the hippocampal system in primates and the song system in birds. Specific topics include forms and principles of animal learning, animal conditioning paradigms, forms and principles of human learning, similarities and differences between animal and human learning paradigms, dysfunctions of human memory, human reinforcement learning, hippocampal plasticity and dopamine systems, hippocampal cellular plasticity, hippocampal plasticity and spatial learning, imprinting and song learning in song birds.

Teaching formats:
4 obligatory lectures (three of 3 SWS each, one of 2 SWS)
1 obligatory practicals (2 SWS and 1 SWS)
1 elective tutorial (2 SWS).
All taught in English.

Semesters offered:
103 and 104 every WS, 113 and 114 every SS
Duration:
2 semesters

Prerequisites 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: 196h (=14 SWS). Independent study: 254h. Total: 450h (=15 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: 15 CP obligatory plus 2 CP elective
103: 3 CP lecture und 1 CP practical, plus 2 CP tutorial (elective)
104: 3 CP lecture
113: 3 CP lecture und 2 CP practical
114: 3 CP lecture

Assessment and examinations:
Mastery of course materials is assessed in written examinations (K120) for lectures 103 and 113 and in lab reports (EB) for practicals 103 and 113. Tutorial 103 is not assessed. Also not assessed are lectures 104 and 114, as they offer exemplary glimpses of more advanced research topics rather than foundational knowledge and understanding.
The final module grade is the CP-weighted average of all graded assessments (written examinations and lab reports).
103 lecture: written exam 120 min (K120); *103 practical:* lab report (EB)
113 lecture: written exam 120 min (K120); *113 practical:* lab report (EB)

Module coordinators:
Prof. J. Braun, Prof. H. Scheich.

Module lecturers: PD J. Bock, Prof. J. Braun, Prof. K. Braun, Prof. E. Düzel, PD T. Munsch, Prof. M. Hoffmann, Prof. F. Ohl Prof. H. Scheich, Prof. A. Schönfeld, PD Dr. P. Heil, Dr. T. Endres, PD Dr. M. Brosch, Dr. A. Richardson-Klavehn, PD Dr. V. Korz and others.
Recommended literature: *103:* Watson, Kirkcaldie, Paxinos, “The Brain: an Introduction to Functional Neuro-anatomy”, 2010 Striedter “Principles of Brain Evolution”, 2004 *104:* Heiligenberg, “Neural Nets in Electric Fish”, 1991 Tomasello and Call, “Primate Cognition”, 1997 *113:* Units II and III in Purves at al., eds., “Neuroscience”, 5th edition, 2011 Parts IV and V in Kandell, Schwartz, Jessell, “Principles of Neural Science”, 5th edition, 2012 *114:* Eichenbaum and Cohen, “From Conditioning to Conscious Recollection”, 2001 Andersen, Morris, Amaral, et al., “The Hippocampus Book”, 2006

Degree programme:
MSc Integrative Neuroscience

Module GC (12 CP obligatory and 8 CP elective):
Fundamental theoretical and computational neuroscience

Module aims and learning outcomes:
At the end of this large and important 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 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), models of network dynamics (state-space analysis and eigenvalue analysis of steady-states), models of Hebbian plasticity and of 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). Similarly, 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).

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 competences in judging complex information, learning independently and communicating in a scholarly context.

Module assessment:
The course material is assessed in the form of four written exams, in order to offer detailed feedback about learning performance. On the basis of this feedback, students can identify and remedy any deficiencies before progressing to module VC. To avoid penalizing students with a weaker background in this area, students may choose to have two assessments recorded as pass/fail.

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 and additional questions about the lecture materials.

Module components:

<u>105 Theoretical neuroscience I (3 SWS lecture, 2 SWS tutorial as elective)</u>

Based on Chapters 5-6 and Chapters 1-4 of Dayan & Abbott. Electrochemical equilibrium and Nernst Equation, equivalent circuits for single-compartment model, leaky integrate-and-fire model, Hodgkin-Huxley and Connor-Stevens models of action potential, cable equation and neuron morphology, characterizing neuronal responses with tuning curves and receptive fields, signal-detection theory and psychometric function, comparision 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 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.

<u>106 Mathematical foundations (2 SWS lecture, 2 SWS tutorial as elective)</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, 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>115 Theoretical neuroscience II (3 SWS lecture, 2 SWS tutorial as elective)</u>

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.

116 Biological statistics (2 SWS lecture, 2 SWS tutorial as elective) 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. 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: 4 obligatory lectures (two of 3 SWS each, two of 2 SWS). 4 elective tutorials (2 SWS each). All taught in English.
Semesters offered: 105 and 106 every WS, 115 and 116 every SS **Duration:** 2 semesters
Prerequisites 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: 140h (=10 SWS). Independent study: 220h. Total: 360h (=12 CP). **Time investment elective components:** Face-to-face: 112h (=8 SWS). Independent study: 128h. Total: 240h (=8 CP).
Credit points: *Total number of credit points: 12 CP obligatory plus 8 CP elective* *105:* 3 CP lecture plus 2 CP tutorial (elective) *106:* 3 CP lecture plus 2 CP tutorial (elective) *115:* 3 CP lecture plus 2 CP tutorial (elective) *116:* 3 CP lecture plus 2 CP tutorial (elective)
Assessment and examinations: Mastery of course materials is assessed in homework assignments (HA) and in written examinations (K120). Tutorials are not assessed. Homework assignments are assessed pass/fail. Students must pass all assignments to be admitted to the written exam. Written exams are graded, but students may choose to have two assessments recorded as pass/fail. The final module grade is the CP-weighted average of all graded assessments (written examinations). *105 lecture*: weekly homework assignments (HA), written exam 120 min (K120). *106 lecture*: weekly homework assignments (HA), written exam 120 min (K120). *115 lecture*: weekly homework assignments (HA), written exam 120 min (K120). *116 lecture*: weekly homework assignments (HA), written exam 120 min (K120).
Module coordinators: Prof. J. Braun, Prof. R. Schwabe. **Module lecturers:** Prof. J. Braun, Prof. A. Pott, Prof. R. Schwabe, Prof. A. Wendemuth and others.

Recommended literature:

105:

Dayan & Abbott, “Theoretical Neuroscience”, 2001
Sterrat, Graham, et al., “Principles of Computational Modelling in Neuroscience”, 2011

106:

Batschelet, “Introduction to Mathematics for Life Scientists”, Springer, 1973
Gabbiani & Cox, “Mathematics for Neuroscientists”, 2010
Ermentrout & Terman, “Mathematical Foundations of Neuroscience”, 2010

115:

Dayan & Abbott, “Theoretical Neuroscience”, 2001
Wilson, “Spikes, Decisions, Actions: the Dynamical Foundations of Neuroscience”, OUP 1999
Sutton & Barto, “Reinforcement Learning: an Introduction”, MIT Press, 1999

116:

Bland, “An Introduction to Medical Statistics”, Oxford UP, 1995
Ross, “Introduction to Probability and Statistics for Engineers and Scientists”, Wiley, 1987
Jaynes, “Probability Theory: the Logic of Science”, Cambridge, 2003

Degree programme:
MSc Integrative Neuroscience

Module VA (16 CP elective):
Advanced molecular and cellular neuroscience I

Module aims and learning outcomes:
This module consists of four elective components. After taking each component, students will have advanced knowledge and understanding in molecular and cellular neuroscience. Specifically, they will be able to recognize, organize and explain the production and application of mutants to the study of neurobiological function and dysfunction (201), the function and dysfunction of the immune systems in the central nervous system (203), theoretical approaches to designing research on neural signal transduction (205), and the quantitative study and analysis of neurobiochemical signal chains (207). In addition, students will have acquired advanced practical and applied skills in molecular and cellular neuroscience. Specifically, they will be able to explain, demonstrate, and apply genetic models of disease (201), approaches to neurological immune disorders (203), alternative approaches to the research on neural signal transduction (205), and quantitative characterization of neurobiochemical signal chains (206).

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

Module components:
201 Genetic models (1 SWS lecture, 2 SWS practical work, both elective)
Analysis of genetic variants and rare genetic diseases in humans. Design, development and analysis of genetic models 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.

203 Neuroendocrinolog, -inflammation, and CNS diseases (1 SWS lecture, 2 SWS practical work, both elective)
Our course explores terminology, cells, tissues and organs of the neuroendocrine and immune systems; signalling in the neuroendocrine and immune systems (hormones, cytokines) and feedback-mechanisms; synthesis of peptides as extracellular signals, mechanisms of peptide processing and secretion; cell biology and immune functions of microglia, protective immunity in the CNS, selected neuroendocrine diseases, neuroinflammation and alterations of the CNS caused by pathogen microbes. In addition, the practical part of the course introduces students to infectious and tu-

mour diseases of the CNS.

205 Neural signalling (1 SWS lecture, 2 SWS tutorial, both elective)
The lectures introduce potential research projects concerning the principles and molecular mechanisms of information transmission in the nervous system as well as downstream intracellular signalling pathways. Students choose individual topics and develop and plan a small research project on this topic. In the tutorial, students prepare a detailed research proposal and short seminar presentation on their chosen topic.

206 Quantitative signal transduction (1 SWS lecture, 2 SWS practical work, both elective)
Participants learn quantitative analysis methods for signal transduction chains, as well as the critical evaluation of results with respect to various methodological problems. A second focus lies on applications in the area of systems biology. In the practical part, participants monitor 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.

Other courses:
In addition to the courses listed above, 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 (4 CP). However, students are cautioned to beware of possible schedule conflicts.

Teaching formats:
4 elective lectures (1 SWS each)
4 elective practical works (2 SWS each)
All taught in English.

Semesters offered:
Every WS
Duration:
1 semester

Prerequisites for participation:
Module GA

Time investment elective components:
Face-to-face: 168h (=12 SWS). Independent study: 312h. Total: 480h (=16 CP).

Credit points:
Total number of credits 12 CP elective
201: 2 CP lecture plus 2 CP practical work, both elective
203: 2 CP lecture plus 2 CP practical work, both elective
205: 2 CP lecture plus 2 CP practical work, both elective
206: 2 CP lecture plus 2 CP practical work, both elective

Assessment and examinations:
Mastery of course materials is assessed in different ways, at the discretion of the responsible lecturer. Possible formats are written exam 60 min (K60), and/or seminar presentation 30 min (SV30), and/or homework assignments (HA), and/or lab report (EB). All assessments are graded. The final module grade is the CP-weighted average of all graded assessments.

201: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).
203: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).
205: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).
206: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).

Module coordinators:
Prof. E. Gundelfinger, Prof. V. Leßmann.
Module lecturers:
Prof. D. Dieterich, Prof. M. Engelmann, Prof. K. Fischer, Prof. E. Gundelfinger, Prof. V. Leßmann, Prof C. Mawrin, Prof. G. Reiser, Prof. F. Schaper, PD C. Seidenbecher, Prof. O. Oliver Stork, PD U. Thomas, PD M. Zenker and others.

Recommended literature:
201:
Krebs, Goldstein, et al., “Genes X”, Jones & Bartlett Pubs (2009)
Watson, Baker, et al., “Molecular Biology of the Gene”, Pearson (7th ed., 2013)
203:
Fink, Levine, Pfaff, “Handbook of Neuroendocrinology”, Academic Press (2011)
205:
Original research literature and reviews as distributed during the course.
206:
Krauss, “Biochemistry of Signal Transduction and Regulation”, Wiley-VCH (2008)
Gomperts, Kramer, Tatham, “Signal Transduction”, Academic (2009)
Methodik (dicht an den exemplarischen Versuchen des Praktikums):
Nicholson, Nicola, eds. “JAK-STAT Signalling – Methods and Protocols”, Humana (2013)

Degree programme: **MSc Integrative Neuroscience**
Module VB (12 CP elective): **Advanced systems and behavioural neuroscience**
This module consists of three elective components. After taking each component, students will have advanced knowledge and understanding in systems and behavioural neuroscience. Specifically, they will be able to recognize, organize and explain current research approaches to perception, attention, language and executive functions (211), current research approaches to imaging macroscopic brain function (215), or current research approaches to imaging microscopic brain functions (217). Components 215 and 217 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 behavioural experiments on perceptual choice tasks (211), different modalities of macroscopic imaging (215) or modern microimaging techniques with state-of-the-art instrumentation (217). **Module assessment:** The course material is assessed in different ways, selected 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:** 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 competences in critical analysis and synthesis of complex information (‘judging’) and in assuming responsibility for, and leadership of, joint research projects (‘communicating’).
Module components: **<u>211 Cognitive neurobiology (2 SWS lecture, 1 SWS practical work, both elective)</u>** 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 and executive processing, neural activity dynamics, special navigation, social interactions, and consciousness. In the practical part, students perform, analyze, and evaluate visual psychophysical experiments (choice task, staircase procedure, psychometric function fit, bootstrapping to estimate parameter confidence). **<u>215 Macroimaging (2 SWS lecture, 1 SWS practical work, both elective)</u>** Introduction to current methods of imaging macroscopic brain activity. Complements 217. Physical bases and principles of EEG, MEG, and MRI. Physiological basis of hemodyamic 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.

217 Microimaging (1 SWS lecture, 2 SWS practical work, 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.

Other courses:
In addition to the courses listed above, 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 (4 CP). However, students are cautioned to beware of possible schedule conflicts.

For example, subject to case-by-case permission of the instructor, students may participate in the following course offered in the degree programmes “MSc Philosophy, Neuroscience, Cognition” and “MSc Psychology”:

Cognitive Neurobiology (2SWS lecture, 2CP)
Neurobiology of Consciousness (2SWS lecture, 2CP)

Perception (H2 Perception, 2 SWS seminar, 4 CP)
Psychophysiology (H3 Cognitive Neuroscience, 2SWS seminar, 4CP)
Biological Psychology (I1 Biologische Psychologie, 2 SWS, 4 CP)
Psychophysiology (J1 Psychophysiologie, 2 SWS seminar, 4 CP)
Emotion and Motivation (J2 Emotion und Motivation, 2 SWS seminar, 4 CP)

Teaching formats:
3 elective lectures (1 or 2 SWS each)
3 elective practical works (1 or 2 SWS each)
All taught in English.

Semesters offered:
Every WS
Duration:
1 semester

Prerequisites for participation:
Module GB

Time investment elective components:
Face-to-face: 126h (=9 SWS). Independent study: 232h. Total: 360h (=16 CP).

Credit points:
Total number of credit points: 12 CP elective
211: 2 CP lecture plus 2 CP practical work, both elective
215: 2 CP lecture plus 2 CP practical work, both elective
217: 2 CP lecture plus 2 CP practical work, both elective

Assessment and examinations:

Mastery of course materials is assessed in different ways, at the discretion of the responsible lecturer. Possible formats are written exam 60 min (K60), and/or seminar presentation 30 min (SV30), and/or homework assignments (HA), and/or lab report (EB). All assessments are graded. The final module grade is the CP-weighted average of all graded assessments.
211: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).
215: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).
217: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).

Module coordinators:
Prof. J. Braun, Prof. J.-M. Hopf

Module lecturers:
Prof. J. Braun, Prof. J.-M. Hopf, PD R. König, Prof. A. Schönfeld, Prof. O. Speck, Dr. C. Tempelmann, Prof. G. Reiser, Prof. T. Voigt and others.

Recommended literature:

211:
Purves, Brannon, et al., “Principles of Cognitive Neuroscience”, Macmillan (2008)
Gazzaniga, Ivry, Mangun, “Cognitive Neuroscience”, WW Norton (2013)
215:
Haake, Brown, et al., “Magnetic Resonance Imaging: Physical Principles and Sequence Design”, Wiley (2013)
217:
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 VC (4 CP elective):
Advanced theoretical and computational neuroscience

Module aims and learning outcomes:
This module consists of one elective component. Further components are offered in the context of other MSc degree programmes (e.g., physics, informatics, process engineering, electrical engineering). After taking each component, students will have advanced knowledge and understanding in areas relevant to theoretical and/or computational neuroscience.

Specifically, they will be able to recognize, organize and explain the analysis of stochastic dynamical systems, such as a recurrently connected network of spiking neurons (221).

In addition, students will have acquired advanced practical and applied skills in theoretical and computational neuroscience. Specifically, they will be able to explain, demonstrate, and apply both simulation techniques and mean-field analysis methods to the dynamics of networks of spiking neurons (221).

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 competences in critical analysis and synthesis of complex information (‘judging’) and in assuming responsibility for and leadership of, joint research projects (‘communicating’).

Module components:
221 Spiking networks (2 SWS lecture, 1 SWS practical work, both elective)
Special mathematical and statistical tools are required to model and analyze biologically plausible networks of spiking neurons. The course offers a step-by-step introduction to stochastic dynamical systems up to and including current mean-field approaches to recurrent networks of spiking neurons. Stochastic variables, stochastic processes, interval distributions, autocorrelation and power spectrum, Wiener process and white noise, LIF neurons with Poisson input, diffusion limit, Fokker-Planck equation of VIF neuron, mean-field theory of recurrently connected populations, application to decision making and confidence. In the practical part, students simulate and analyze recurrent networks of spiking neurons on the basis of Matlab and Neuron.

Other courses:
In addition to the courses listed above, 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 (4 CP). However, students are cautioned to beware of possible schedule conflicts.

Students are encouraged to consult the courses offered in physics (FNW), electrical engineering (FEIT), process engineering (FVST), and informatics (FIN), which include:

Computer simulation (lecture and tutorial, 4SWS, FNW)
Biophysics (lecture and tutorial, 4 SWS, FNW)
Bioinformatics (lecture and tutorial, 3 SWS, FIN)
Machine Learning (2 SWS, 5CP FIN)
Fuzzy Systems (2 SWS, 6CP FIN)
Numerical methods (3SWS, FVST)
Molecular modelling (lecture and tutorial, 3SWS, FVST)
Stochastic processes (lecture and tutorial, 4 SWS, FVST)
Theoretical systems biology (lecture and tutorial, 3 SWS, FVST)

Teaching formats:
1 elective lectures (2 SWS each)
1 elective practical works (1 SWS each)
All taught in English.

Semesters offered:
Every WS
Duration:
1 semester

Prerequisites for participation:
Module GC

Time investment elective components:
Face-to-face: 42h (=3 SWS). Independent study: 78h. Total: 120h (=4 CP).

Credit points:
Total number of credits 4 CP elective
221: 3 CP lecture plus 1 CP practical work, both elective

Assessment and examinations:
Mastery of course materials is assessed in different ways, at the discretion of the responsible lecturer. Possible formats are written exam 60 min (K60), and/or seminar presentation 30 min (SV30), and/or homework assignments (HA), and/or lab report (EB). All assessments are graded. The final module grade is the CP-weighted average of all graded assessments.

221: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).

Module coordinators:
Prof.J. Braun, Prof. O. Speck
Module lecturers:
Prof. J. Braun

Recommended literature:
221:
Gerstner, Kistler, “Spiking Neuron Models”, Cambridge (2002)
Papoulis, Pillai, “Probability, Random Variables, and Stochastic Processes”, McGrawHill (2002)
Rolls, Deco, “The Noisy Brain”, Oxford UP (2010)

Degree programme: **MSc Integrative Neuroscience**
Module VD (12 CP elective): **Advanced clinical and applied neuroscience**
Module aims and learning outcomes: This module consists of three elective components. After taking each component, students will have advanced knowledge and understanding in clinical and/or applied neuroscience. Specifically, they will be able to recognize, organize and explain neurochemical and neuropharmacological aspects of brain function (214, from the level of genetics to the level of systems, including a systematic appreciation of the different aspects of transmitter, neuromodulator and hormone function), the systematic etiology of psychic disorders (241: including genetic, developmental, traumatic, organic, metabolic and endogenous causes), and studies of human cognition and emotion with non-invasive imaging techniques (242). In component 214, students will also have acquired advanced practical and applied skills in systems and behavioural neuroscience. Specifically, they will be able to explain, demonstrate, and conduct neuropharmacological experiments. **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:** 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 competences in critical analysis and synthesis of complex information (‘judging’) and in assuming responsibility for, and leadership of, joint research projects (‘communicating’).
Module components: **<u>214 Behavioural neuropharmacology (2 SWS lecture und 1 SWS practical work, both elective)</u>** The course offers 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 of hormones related to brain function are discussed. Major topics are pharmacological aspects of learning and memory, emotional behaviour, neuronal plasticity, stress and addiction. For each topic, neuroanatomical (brain regions and cell populations), neurophysiological (activity, plasticity, intracellular signals), molecular (genetic and proteomic functions), and neuropathological aspects are covered. The practical course introduces students to neuropharmacological experiments. Changes of different behavioural parameters (i.e. motoric, emotional) after drug application will be analyzed.

241 Clinical neuroscience (3 SWS lecture, elective)
Introduction to clinical neuroscience, including presentation of suitable patients (when possible). 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. Psychopharmacology: Neurobiological foundations and clinical effects.
242 Cognitive neuroimaging (3 SWS lecture, elective)
Introduction to the study of human cognition and emotion with non-invasive imaging techniques. One focus concerns the functional anatomy of higher cognitive functions such as memory, attention, and social interactions. A second focus concerns selected neuropsychiatric symptoms, the affected brain regions, and the associated dysfunctions.

Other courses:
In addition to the courses listed above, 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 (4 CP). However, students are cautioned to beware of possible schedule conflicts.

For example, subject to case-by-case permission of the instructor, students may participate in the following course offered in the degree programme “MSc Psychology”:

4 Diseases of the CNS (G1 Krankheiten des ZNS, 2 SWS lecture, 4 CP)
5 Psychopharmacology (G2 Psychopharmakologie, 2 SWS lecture, 4 CP)

Teaching formats:
3 elective lectures (2 SWS or 3 SWS each).
1 elective tutorial (1 SWS each).
All taught in English.

Semesters offered:
Every WS
Duration:
1 semesters

Prerequisites for participation:
Modules GA1, GA2, GB, GC

Time investment elective components:
Face-to-face: 126h (=9 SWS). Independent study: 234h. Total: 360h (=8 CP).

Credit points:
Total number of credit points: 12 CP elective
214: 3 CP lecture plus 1 CP tutorial, both elective
241: 4 CP lecture, elective
242: 4 CP lecture, elective

Assessment and examinations:
Mastery of course materials is assessed in different ways, at the discretion of the responsible lecturer. Possible formats are written exam 60 min (K60), and/or seminar presentation 30 min (SV30), and/or homework assignments (HA), and/or lab report (EB). All assessments are graded. The final module grade is the CP-weighted average of all graded assessments.
214: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).

241: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB). 242: written exam 60 min (K60), seminar presentation 30 min (SV30), homework assignments (HA), lab report (EB).
Module coordinators: Prof. B. Bogerts, Prof. K. Braun. **Module lecturers:** Prof. B. Bogerts, Prof. K. Braun, PD Dr. Martin Walter, Prof. J-M Hopf, Prof. A Schönfeld, Dr. T. Endres, PD Dr. J. Bock, PD Dr. V. Korz and others.
Recommended literature: *214:* Nestler, Hyman & Malenka, "Molecular Neuropharmacology", McGrawHill Medical (2008). *241:* Charney, Nestler, eds., "Neurobiology of Mental Illness." Oxford UP (2011) *242:* Lazar, "The Statistical Analsysis 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 Neuroscienctists", Springer (2010)

Degree programme:
MSc Integrative Neuroscience

Module X (20 CP obligatory, 5 CP optional):
Professional key competences

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 of conducting neuroscience research and in communicating its results in written and oral form. *Scientific writing* provides extensive coaching in structuring, composing, and persuading with a scientific text. *Philosophy and ethics of science* provides experience in judging and resolving complex situations characterized by conflicting values and interests. *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 competences. 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 renegotiate 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:

190 Lab rotations I, II, and III (11 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 thesis. All research groups and Institutes participating in the MSc Integrative Neuroscience programme may supervise lab rotations.

300 Scientific writing (2 SWS tutorial, 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, 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.

350 Philosophy and ethics of science (2 SWS lecture, obligatory)

Covers the methods, foundations, and conclusions of science and topics of scientific ethics. Includes induction, hypotheticiy 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).

107 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 seminar, 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 seminar, optional)

Regular research seminars of research institutes, ‘Sonderforschungsbereiche’, ‘Forschungsverbünde’, and the Leibniz Institute of Neurobiology.

101, 102, 103, 111, 113 practical work (12 SWS/12CP obligatory)
101, 102, 103, 105, 106, 111, 112, 115, 116, 205 tutorials (18 SWS/18CP elective)
201, 203, 206, 211, 215, 217, 221, 214 practical work (12 SWS/12CP elective)

As integral parts of other modules, the degree programme comprises 5 obligatory and 8 elective practical courses as well as 10 elective tutorials. All of these practical courses and tutorials convey professional key competences, in addition to knowledge and understanding in specific areas of integrative neuroscience.

Teaching formats:
190: three obligatory practical courses (3 or 4 SWS)
300: obligatory tutorial (2 SWS)
350: obligatory lecture (2 SWS)
197, 180, 185: optional seminars (2 SWS each)
All taught in English.

Semesters offered:
190: every semester
300: every SS
350: every WS
107: every WS
180, 185: every semester

Prerequisites for participation:
None.

Time investment core components (without integral parts of other modules)
Face-to-face: 210h (=15 SWS), Independent study: 390h, Total: 600h (=20 CP).
Time investment elective components (without integral parts of other modules)
Face-to-face: 84h (=6 SWS), Independent study: 66h, Total: 150h (=5CP).

Credit points (without integral parts of other modules):
Total number of credit points: 18 CP obligatory plus 6 CP optional
190: 16 CP practical work, obligatory
300: 2 CP tutorial, obligatory
350: 2 CP lecture, obligatory
107: 2 CP seminar, optional
180: 2 CP seminar, optional
185: 1 CP seminar, optional

Assessment and examinations:
Mastery of course materials is assessed in homework assignments (HA), lab reports (EB), and seminar presentations (SV30). All assessments are pass/fail. Seminar 185 is not assessed. The final module grade is pass/fail.

190: lab report (EB) und seminar presentation (SV30)
300: homework assignment (SV30)
350: three written exams (3xK20)
107: homework assignment (HA)
180: seminar presentation (SV30)

Module coordinators:
Prof. J. Braun, Prof. K. Braun
Module lecturers:
Lecturers of other modules.

Recommended literature:
300:
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).

350: Weiss, “The Elements of International English Style”, ME Sharpe (2005) Katz, “From Research to Manuscript: A Guide to Scientific Writing”, Springer Netherlands (2008) Glasman-Deal, “Science Research Writing: for Non-Native Speakers of English”, Imperial College Press (2010) Raimes, Jersky, “The Open Handbook”, Houghton Mifflin Company (2009). Matthew, Matthews, Bown, “Successful Scientific Writing. A Step-by-Step Guide for the Biological and Medical Sciences”, Cambridge UP (2007)

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 a 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 of extending 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 pertaining to a circumscribed research area. In particular, an ability to integrate and structure complex neuroscientific information, to identify and to justify key aspects of a neuroscientific research question, to compare and choose between alternative paths of action, and to formulate and justify judgements on the basis of partial or preliminary information. To be contrasted with the capability for critical analysis and synthesis of complex information pertaining to 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, to deepen and enlarge one's knowledge, to integrate newly acquired information with prior knowledge, and to apply newly acquired information to a circumscribed research area. Also includes an ability to rate correctly one's knowledge level, to identify and to 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 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.