HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

Module Handbook

Study Programme
Master of Science in
Translational Neuroscience

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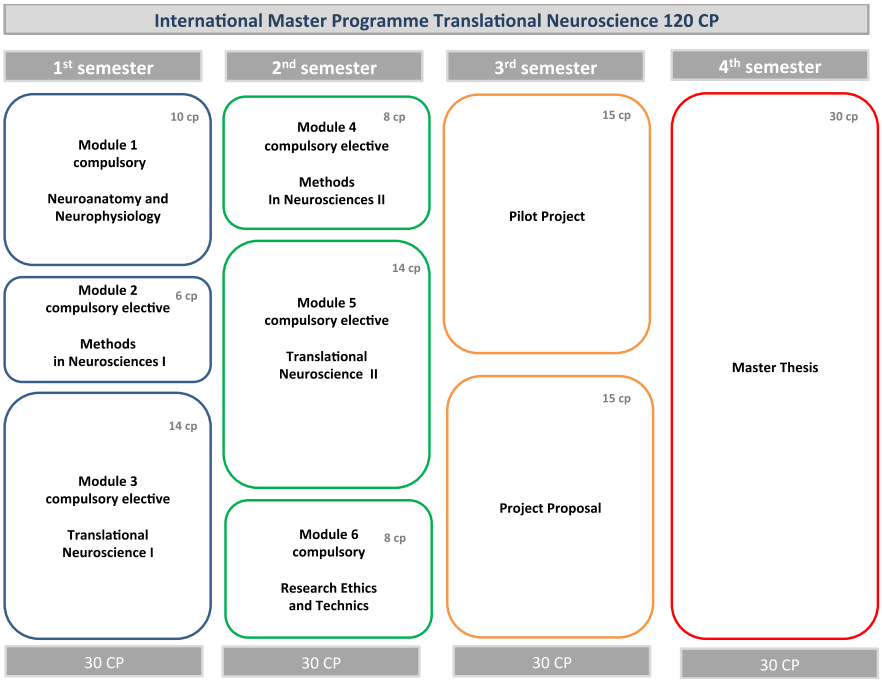
Contents

Course Overview



Module 1 (10 CP) compulsory: Neuroanatomy and Neurophysiology
Module 2 (6 CP) compulsory elective: Methods in Neurosciences I
- **Module 2a**: Foundations of Medical Physics
- **Module 2b**: High-Throughput Analysis: Genomics and Proteomics
- **Module 2c:** Laboratory Animal Course
- **Module 2d**: Non-Mammalian Model Systems of Neurodegenerative Diseases

Module 3 (14 CP) compulsory elective: Translational Neuroscience I
- **Module 3a**: Neurocytology, cell differentiation and regeneration of the nervous system
- **Module 3b:** Cellular and Molecular Analyses of Brain Function
- **Module 3c:** Cognitive Neuroscience

Module 4 (8 CP) compulsory elective: Methods in Neurosciences II
- **Module 4a**: Experimental and Translational Neuroimaging
- **Module 4b**: Methods in Neurosciences

Module 5 (14 CP) compulsory elective: Translational Neuroscience II
- **Module 5a:** Neuroimmunology
- **Module 5c:** Systems Neuroscience

Module 6 (8 CP) compulsory: Research Ethics and Technics
Pilot Project (15 CP) compulsory:
The pilot project is a 12-week placement in a laboratory, which serves to demonstrate research activities in the working groups. Students are assigned to a specific project on which they can work under one-to-one supervision.
Project Proposal (15 CP) compulsory:
The project proposal is an 8-week a placement in a laboratory, which serves as a preparatory exercise for the Master's thesis. After its completion, a concept (project sketch) for the Master's thesis is to be drawn up.
Master's Thesis (30 CP) compulsory:
The Master's thesis is a 6-month experimental work based on the project proposal. Students complete the experimental working phase with a concluding thesis and a colloquium.

General Information

This Masters programme in Translational Neuroscience is an international study programme and lectures and examinations are held in English. Therefore sufficient command of the English language is required. This proficiency in English should be at least the level B2 of the Common European Framework of Reference for Languages (CEFR).

The study programme consists of 6 Master modules followed by two practicals and is concluded with a 6-month Master's thesis. The first and the last Master module "Neuroanatomy and Neurophysiology" and "Research Ethics and Technics" are compulsory. Modules of area 2 through 5 are compulsory electives and one of them must be chosen, e.g. from area 2 "Methods in Neuroscience I" either Module 2a or 2b or 2c or 2d. Depending on the individual interest in potential future occupational areas different study foci are offered:

- **Neuroimaging**
- **Regeneration of CNS Traumata**
- **Molecular Basis of Brain Development, Neurodegeneration and Disease**

For each study focus the following combinations of compulsory and compulsory elective modules are recommended:

Neuroimaging:
- 1 Neuroanatomy and Neurophysiology
- 2a Foundations of Medical Physics
- 3c Cognitive Neuroscience
- 4a Experimental and Translational Neuroimaging
- 5c Systems Neurosciences or alternatively 5a Neuroimmunology
- 6 Research Ethics and Technics

Regeneration of CNS Traumata:
- 1 Neuroanatomy and Neurophysiology
- 2c Laboratory Animal Course
- 3a Neurocytology, cell differentiation and regeneration of the nervous system
- 4b Methods in Neurosciences
- 5a Neuroimmunology
- 6 Research Ethics and Technics

Molecular Basis of Brain Development, Neurodegeneration and Disease:
- 1 Neuroanatomy and Neurophysiology
- 2d Non-Mammalian Model Systems of Neurodegenerative Diseases or 2b High-Throughput Analysis: Genomics and Proteomics or 2c Laboratory Animal Course
- 3a Neurocytology, cell differentiation and regeneration of the nervous system or 3b Cellular and Molecular Analyses of Brain Function
- 4b Methods in Neurosciences
- 5a Neuroimmunology or 5c Systems Neurosciences
- 6 Research Ethics and Technics.

Module Number	**Title:**		
1	**Neuroanatomy and Neurophysiology**		
Module type: compulsory	**Language:** English		**Group Size:** 20 students
Study semester: 1	**Availability:** winter semester		**Duration:** 1 semester
Workload: 300 hrs	**Credits:** 10 CP	**Contact time:** 84 hrs	**Independent Study:** 216 hrs

1 Courses

a) Lectures 4 PPW
b) Practical course 3 PPW
c) Seminars 1 PPW

2 Intended Learning Outcomes

This first module will provide a common basis in neuroscience for all students being admitted from diverse BSc study programmes. Upon completion of this course the students should be able to describe and characterize the structural and functional organization of the nervous system and the neural basis of perception and movement. They are capable to localize those regions in post mortem brain tissue and in vivo brain images. They are capable to describe the molecular and cellular mechanisms, by which neurons code and convey information, how these mechanisms are modified by experience or disturbed by exemplary disease states. Students will be capable of applying these neurophysiologic basics to in vivo recordings of brain and muscle function. Students will be able to explain the working principles of selected perceptive organs (visual system, auditory system) and skeletal muscles.

3 Content

Preparatory self-study time:

In preparation to the topics presented in the lectures, practical courses and seminars, students will have one week prior to the official start of the module for focusing on the ontogenetic development of the human brain (Prereading Material: Keith L. Moore, Mark G. Torchia, T. V. N. Persaud; The Developing Human: Clinically Oriented Embryology; 10th edition, chapter 17 "Nervous System", pages 379-415). These topics will then be recapitulated at the beginning of the lectures and are relevant for passing the exam of the module.

Lectures:

The lectures will cover general principles in neuroanatomy and neurophysiology, sensory and motoric systems and integrative components of the nervous system and will highlight their relevance for clinical neurology. Specific topics in neuroanatomy cover: development of the nervous system, general structure of the human central and peripheral nervous system, organization of the brain based on the cellular and molecular architecture, cortical divisions and related functions, special senses and dedicated functional systems, spinal cord organization with ascending and descending fiber tracts, brain stem, cerebellum, diencephalon, basal ganglia, vascular blood supply, and cerebrospinal fluid system. Specific topics in physiology cover: molecular and cellular neurophysiology (properties of biological membranes, membrane potential, action potential, electrical and chemical synaptic transmission, somatodendritic integration, synaptic plasticity); skeletal muscle physiology (neuromuscular junction, electro-mechanical coupling, muscle mechanics; reflexes); sensory physiology (phototransduction, mechanotransduction, receptive field organization, central processing of sensory information); pathophysiologic principles (channelopathies, demyelination, basal ganglia degeneration, etc.). The lectures will conclude with histology, basics of human genetics and pathology (inherited, degenerative, inflammatory and oncological neurological diseases).

Practical courses:

Accompanying practical and theoretical exercises will deepen the lecture topics. The practical course in anatomy will concentrate on gross anatomy and histology of the human brain and spinal cord. Histology will cover examples of light microscopy as well as specific aspects of high-resolution methods such as electron microscopy and

	polarized light imaging. Gyri and sulci as well as the components of different functional systems will be identified in post-mortem brain sections. This knowledge will be transferred from basic neuroanatomy to neuroimaging and clinical applications using series of MR images. The practical course in physiology will cover the intrinsic properties of excitable membranes, the recording and interpretation of extracellular potentials in humans (EMG, EEG), and the clinical examination of the nervous and selected sensory systems. Students will perform the following methods: • Identification of different brain structures in hemispheres and sections on post-mortem brain and their association with functional systems • Microscopic delineation of brain areas in post-mortem brain sections • Cortex delineation on MR images • Recording and Interpretation of extracellular potential in humans (EMG, EEG) • Clinical examination of the nervous and selected sensory systems • Electrophysiological analysis of cellular electrical signals and synaptic transmission • Measurements of intracellular [Cl^-] in glioblastoma cells • Psychophysiological analysis of pain perception and somatic senses • Nerve propagation velocity, Hoffmann reflex (H-reflex) analysis **Seminars:** The seminars will focus on specific aspects of neuroanatomy and –physiology, which will allow students to apply their acquired knowledge to gain insight into more complex cognitive processes such as pain perception, communication, timing and music, as well as in a more detailed understanding of normal and pathologically altered synaptic transmission. Students will work on these topics based on prepared material and literature, enabling them to appreciate the relevance of a profound basis in neuroanatomy and –physiology for the evaluation of neuroimaging findings and mechanistic theories. **Recommended reading, lecture notes:** Jürgen Mai, George Paxinos: “The Human Nervous System”, Oxford University Press; Rudolf Niewenhuys, Jan Voogd, Christiaan van Huijzen: “The Human Central Nervous System: A Synopsis and Atlas”, Steinkopff / Springer; Mark Bear, Michael Paradiso, Barry W. Connors: “Neuroscience: Exploring the Brain”, Lippincott Williams & Wilki; J. Edward Bruni, Donald G. Montemurro: “Human Neuroanatomy: A Text, Brain Atlas, and Laboratory Dissection Guide” Oxford University Press; “Grey’s Anatomy” sections 3 and 4; Hammond “Molecular and Cellular Neurophysiology"
4	**Teaching methods** Lecture and practical training with accompanying theoretical exercises and seminars, self-study.
5	**Prerequisites** A Bachelor or equivalent certificate in neurosciences or natural sciences, or a medical degree (MD)**;** Basic knowledge in cell biology, biochemistry, and physics**;** Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR)
6	**Examination types** Written exam
7	**Requirements for award of credit points** Regular and active participation in the exercises, practical training and seminars, including participation in the entrance test, presenting the basics during seminars and passing written final examination.

8	**Module applicability (in other study courses)**
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. Katrin Amunts, Dr. Hans-Jürgen Bidmon, Dr. Evelyn Oermann, Dr. Christina Herold, Dr. Nicole Palomero, Prof. Dr. Christoph Fahlke, Dr. Heike Heuer, Dr. Thomas Mühleisen, Prof. Dr. Sascha Weggen, Prof. Dr. Carsten Korth, Prof. Dr. Orhan Aktas, Prof. Dr. Guido Reifenberger
11	**Further information** The regular participation in the lecture is strongly recommended. The content of the lectures is prerequisite for the practicals and the seminars. The module will partly be held at Forschungszentrum Jülich. A bus shuttle between HHU and Jülich will be available.

Module Number **2a**	**Title:** **Foundations Medical Physics**		
Module type: compulsory elective	**Language:** English		**Group Size:** 18 students
Study semester: 1	**Availability:** winter semester		**Duration:** 1 semester
Workload: 180 hrs	**Credits:** 6 CP	**Contact time:** 30 hrs	**Independent Study:** 150 hrs

1	**Courses** a) Lecture: 1 PPW b) Practical Course: 2 PPW
2	**Intended Learning Outcomes** Upon completion of this course, students should be able to describe physics concepts with relevance in medicine and apply these concepts in diagnostics and therapy. After the attendance of this course, students are capable to operate essential medical physics equipment, understand their physics and document and analyse the scientific experiments.
3	**Content** **Lecture:** i. *Physics of x-Ray tomography*. x-ray production, x-ray absorption and scattering, x-ray detection. Image formation. ii. *Magnetic resonance*. Magnetic spins, Larmor frequency, spin resonance, spin interaction, contrast, electromagnetic induction. iii. *Magnetic resonance imaging.* Spin manipulation, spin relaxation, spin-echo and gradient echo imaging techniques. iv. *Ultrasound imaging.* Production and propagation of ultrasounds, imaging, absorption and reflection of ultrasounds, image resolution. v. *Blood flow.* Laminar and turbulent flow, Doppler effect, blood velocity and application to stenosis. **Practical Course:** *i. x-Ray tomography*. 3D imaging and artefacts, absorption and scattering, image formation. ii. *Magnetic resonance.* Measuring of the Larmor frequency, free induction decay, measuring of the relaxation times, effect of contrast substance. iii. *Magnetic resonance imaging.* Spin-echo and gradient echo techniques. Effect of work parameters on the image quality. iv. *Ultrasonic imaging.* Measuring of sizes and distances, 3D-imaging and artefacts. Measuring of the heart rate and cardiac output in a heart model. Ultrasonic control of the eye, using an eye model. v. *Blood flow.* Measuring the blood velocity in an arm-model. Measuring of laminar turbulent flow in continuous and pulsed mode. Stenosis detection and characterisation.
4	**Teaching methods** Lecture on the mathematics and concepts of medical physics and their experimental implementation (block of 15 lessons in one week); carrying out experiments in the laboratory, taking, analysis and interpretation of experimental data in the fields of the content (5 blocks of 5 hrs each).
5	**Prerequisites** **Formal:** Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR) **With regards to content:** Basic knowledge of and interest in mathematics and physics
6	**Examination types** Written report The report should be about 10 pages per experiment, document the familiarity with the experimental work and contain the data taken as well as their analysis.

7	**Requirements for award of credit points** Active participation on practical exercise; passing the oral examination prior to each experiment and submission of a report which gets graded with 4.0 or better four weeks after ending of practical exercise.
8	**Module applicability (in other study courses)** None
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. Thomas Heinzel, PD Dr. Mihai Cerchez
11	**Further information** Pre-reading material will be handed out 2 weeks in advance of the laboratory course. The lecture is scheduled for the week preceding the laboratory course. The content of both the pre-reading material and the lecture is prerequisite for the admission to the experimental equipment. For safety reasons and for the conservation of high-value technical resources prior to each experiment the students will be examined orally regarding the operational principles of the experiment. Successful examination grants permission to start the experiment.

Module Number	Title:
2b	**High-Throughput Analysis: Genomics and Proteomics**

Module type: compulsory elective		**Language:** English	**Group Size:** 8 students
Study semester: 1	**Availability:** Each winter semester		**Duration:** 1 semester
Workload: 180 hrs	**Credits:** 6 CP	**Contact time:** 45 hrs	**Independent Study**: 135 hrs

1	**Courses** a) Lecture: 1 PPW b) Practical course: 3 PPW c) Seminar: 1 PPW
2	**Intended Learning Outcomes** This module consists of a genomics and a proteomics part. Upon completion of the genomics part, the students will be able to describe the various gene regulation mechanisms on the DNA and RNA level and all necessary analytical tools to analyse genes, genomes, and gene expression. The students will be able to perform basic DNA and RNA analyses and they will be capable to describe and explain genome-wide, high-throughput DNA and RNA analyses in order to detect genomic variations and changes in gene expression. After completion of the proteomics part, the students will be able to describe and to apply state-of-the-art proteomic approach facilitating protein mass spectrometry (MS) and will be capable to describe the function of MS. They will be able to describe and apply data analysis for protein identification and quantification. The students will be able to discuss critically the obtained results and present basic aspects of genomics and proteomics in an oral presentation.
3	**Content** The lecture about genomics will cover basic aspects of eukaryotic gene expression and regulation. The theoretical background of PCR, classical Sanger sequencing, DNA microarray analysis, and next generation DNA and RNA Seq analyses will be described. The students will discuss the obtained results in a seminar. The practical course will include: - Isolation and purification of DNA and RNA - Quantitative and qualitative nucleic acid measurements - PCR - DNA Sanger sequencing (detection of genetic variations) - DNA microarray or NGS sequencing analyses (changes in gene expression) In the practical course about proteomics the students will perform all steps for protein identification and quantification comprising: - Sample preparation (lysis, homogenisation, digestion etc.) - Peptide separation by UPLC - Peptide analysis using LC-ESI-MS/MS - Protein identification using data base searches - Protein quantification In the theoretical part the students will get insight into the set-up and function of mass spectrometers and the analysis of quantitative mass spectrometric data.
4	**Teaching methods** Combination of lecture, hands-on practical course and seminar
5	**Prerequisites** **Formal:** Proficiency in English level B2 of Common European Framework of Reference

	for Languages (CEFR) **With regards to content:**
6	**Examination types** Oral presentation
7	**Requirements for award of credit points** Regular and active participation in the practical course; written summary of the practical course; passing the final examination.
8	**Module applicability (in other study courses)** Master Biology
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. Karl Köhrer, Prof. Dr. Kai Stühler, Dr. Gereon Poschmann, Dr. Jessica Schira, Dr. René Deenen
11	**Further information** The regular participation in the lecture is strongly recommended. The content of the lectures is a prerequisite for the practical.

Module Number	**Title:**		
2c	**Laboratory Animal Course**		
Module type: compulsory elective	**Language:** English and German		**Group Size:** 20 students
Study semester: 2	**Availability:** winter semester		**Duration:** 1 semester
Workload: 180 hrs	**Credits:** 6 CP	**Contact time:** 41 hrs	**Independent Study:** 139 hrs

1 Courses

a) Lectures: 2 PPW
b) Practical Course: 2 PPW

2 Intended Learning Outcomes

The students will be capable to identify and describe aspects from the national and EU laws and guidance which regulate the scientific use of animals, the animal welfare, the ethic authorisation process of experiments on animals, the role of animal welfare officer, the control mechanisms of animal experimentation.
The participants will be able to understand and respond appropriately to ethical and welfare issues raised by the use of animals in scientific procedures generally and within their own programme of work. They will be able to understand and to apply the basic principles of the Three Rs.
After completion of this course the trainees are able to describe the biology, husbandry and enrichment, behaviour and reproduction of the main animal species used. Moreover they should be able to provide information on animal health, care and management and possess basic knowledge related to personal health and zoonoses.
The students will be able to recognise different levels of pain, suffering and distress in laboratory animals and will possess knowledge and skills on human methods of killing in accordance with the legislation.
They will be able to formulate and apply appropriate methods of handling, restraint, application and sampling methods relevant to the species used.
The students will be able to describe anaesthesia and minor surgery principles.
They will be able to dissect animals and harvest specific samples for the procedures.
After completion of the course the students should be able to design and perform procedures and projects on animals under consideration of the legal requirements.

The course is accredited by FELASA under Function A, persons carrying out procedures on animals, according to the EU-directive 2010/63/EU. The learning outcomes overall fulfil the requirements under the EU-directive 2010/63/EU for the Function A.

3 Content

Lectures:

Detailed aspects on the following main topics:

- Introduction to laboratory animal science
- Ethical basics for conducting animal experiments
- Legal basics for conducting animal experiments
- Alternative and additional methods to animal experimentation
- Burden in animal experiments
- Biology, physiology, husbandry and care and their influence on animal experiments
- Breeding, genetics and hygiene aspects
- Narcosis, anaesthesia and basic principles of surgery

Practical course:

In the practical course students will perform the following methods:

- Approach, handle/pick up and restrain an animal and return it to its cage/pen in a calm, confident and empathetic manner such that the animal is not distressed or

	caused harm - Recognise normal or desirable behaviour and appearance of the individuals in the context of species, environment and physiological status - Recognise abnormal behaviour and signs of discomfort, pain, suffering, or distress, as well as signs of positive well-being and principles of how pain, suffering and distress can be managed - Proficiently and humanely carry out euthanasia using appropriate techniques on relevant species of laboratory animals - Demonstrate how death is confirmed and how cadavers should be processed or otherwise disposed of - Select and explain the best methods for common procedures (such as blood sampling and application of substances) including route/volume/ frequency as appropriate - Demonstrate that s/he can handle and restrain the animal in the best position for the technique - Perform minor techniques under supervision, in a manner that does not inflict unnecessary pain, suffering, distress or lasting harm - Behaviour, correct handling, identification mark, sexing and age estimation, restrain methods, administration of substances and sampling techniques in different animal species - Husbandry and care in a laboratory animals facility - Narcosis, anaesthesia and basic principles of surgery - Demonstrate competence in surgical techniques, including ablations and incisions and their closure by methods appropriate to the tissue concerned - Euthanasia, necropsy and sampling in small rodents Laboratory animal species: rat, mouse, rabbit, dog, cat.
4	**Teaching methods** Lecture, practical course
5	**Prerequisites** **Formal:** Students that already participated to this course in the last year of a bachelor programme are excluded. **With regards to content:** Participants who have a demonstrable focus on the area of neurosciences
6	**Examination types** Written examination
7	**Requirements for award of credit points** Due to FELASA requirements, attendance during the lecture is mandatory! Regular participation in the theoretical and practical course. A pass in the end-of-module examinations.
8	**Module applicability (in other study courses)** Bachelor and Master Biology
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. Sager, PD Dr. Benten, Dr. Engelhardt, Dr. Benga, Dr. Sehrig-Loven, Prof. Dr. Rosenbruch
11	**Further information** Registration for the practical course will be organised centrally. The lecture is held in German. Slides in English are available on ILIAS. The intended learning outcome of the lectures is prerequisite for the practical. Graduates will receive a course certificate "FELASA - Function A, persons carrying out procedures on animals” in accordance to the EU-directive 2010/63/EU.

Module Number	Title:
2d	**Non-Mammalian Model Systems of Neuronal Development and Disease**

Module type: compulsory elective	**Language:** English	**Group Size:** 6 students
Study semester: 1	**Availability:** Each winter semester	**Duration:** 1 semester

Workload:	**Credits:**	**Contact time:**	**Independent Study**:
180 hrs	6 CP	45 hrs	135 hrs

1 Courses

a) Lecture: 1 PPW
b) Practical course: 3 PPW
c) Seminar: 1 PPW

2 Intended Learning Outcomes

The students are capable to describe the development of the nervous system in non-mammalian animal models such as *Caenorhabditis elegans* and *Drosophila melanogaster.* The students are able to cultivate *Drosophila* and *C. elegans* and to devise experimental strategies to analyse their nervous system by means of state-of-the-art genetic and imaging methods. The students are able to describe basic principles of high throughput methods and quantification of image data. They are able to delineate model systems for neuronal diseases flies as well as amyloid protein aggregation and neurodegeneration in *C. elegans* and evaluate their contribution to the elucidation of respective pathomechanisms in humans.

3 Content

The development of non-mammalian animal models allows for genetic high throughput approaches to elucidate biological interaction networks of neuronal functions. The module ‘Model systems for neuronal development and disease’ aims to make students familiar with non-mammalian animal models and motivate them to take up this innovative research.

Practical course/laboratory:

During the practical course the students will perform the methods listed, respective experiments and data analyses in wild type or reporter invertebrates.

Fruit fly, *Drosophila*:

- Basic methods of *Drosophila* cultivation and genetics

- Basic methods of imaging the fly’s nervous system

- Analyses of gene expression and subcellular protein distribution

- Analyses of gene functions and their role in human diseases

- Analysis of early neurogenesis in the fly

***C. elegans*:**

- Basic methods of *C. elegans* cultivation (solid and liquid culture)

- Basic methods of imaging the nematode’s nervous system at single cell resolution

- Quantification of image data

- Analyses of amyloid protein fibrillation by imaging and biochemistry (immunoblotting, filter retardation assays)

	- Observation of behavioral, biochemical and morphological phenotypes in aging, adult nematodes - Observation of neurodegeneration in single worm neurons
4	**Teaching methods** Lecture, practical course/laboratory work, written protocols
5	**Prerequisites** **Formal** Proficiency in German and English (level B2 of Common European Framework of Reference for Languages (CEFR)) **With regards to content:** None
6	**Examination types** Written exam (70%), protocol (20%), seminar (10%)
7	**Requirements for award of credit points** Participation in the practical course and seminar, delivery of a written protocol, and passed final examination
8	**Module applicability (in other study courses)** Master Biology **Compatibility with other curricula** Master Biochemistry
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. Anna von Mikecz , Prof. Hermann Aberle
11	**Further information** The attendance at the lectures is strongly recommended. The content of the lectures is prerequisite for the practicals, seminar and exam.

Module Number **3a**	**Title:** **Neurocytology, cell differentiation and regeneration of the nervous system**		
Module type: compulsory elective	**Language:** English	**Group Size:** 6 students	
Study semester: 1	**Availability:** winter semester	**Duration:** 1 semester	
Workload: 420 hrs	**Credits:** 14CP	**Contact time:** 124 hrs	**Independent study:** 296 hrs

1	**Courses** a) Lecture 2 PPW b) Practical course 9 PPW
2	**Intended learning outcomes** After completion of this module students (1) will be familiar with the sterile preparation and cultivation of neural stem cells, primary neocortical cell cultures and enrichment/isolation of distinct neural cell types, (2) will able to apply basic immunocytochemical techniques to identify and distinguish neural cell types using light and fluorescence microscopy, (3) will have solid understanding of the development and differentiation of neural cells, (4) will understand the basis of recombinant modulation of endogenous gene expression, (5) will be able to work independently and accurately with laboratory equipment, (6) will be able to analyse and document experimental results according to good scientific practise standards, (7) will be able to present and discuss experimental results and scientific context.
3	**Content** **Lectures:** Neurocytology: Neurons and glial cells - morphology and function in the nervous system, Neural stem cells; Development and differentiation of the nervous system: Induction, Neuro- and gliogenesis, Cell determination, Differentiation and axonal pathfinding, Neurotrophic support and apoptosis; Microglial polarization: Cell fate biofinformatics, CRISPR/CAS9 - gene revolution? Molecular pathophysiology and regeneration: Multiple sclerosis, traumatic nerve injury and regeneration. **Practical course:** The Küry and Müller labs belong to the Department of Neurology and will focus on cultivation and identification of neural cell types from rat brain (neural stem cells, neurons, astrocytes, oligodendrocytes, microglia) and analysis of neural differentiation with the following sets of experiments: Preparation and cultivation of primary cortical mixed cultures; application of light microscopy and immunofluorescence methods to demonstrate morphological cell differentiation and identification of cell maturation markers; Sorting, enrichment and isolation of distinct cell types using MACs or FACS techniques; Cell transfection to modulate endogenous gene expression and cell differentiation; RNA purification and quantification of differentiation markers using pRT-PCR; Polarization of primary microglial cells; Immunoassay (ELISA) to detect secreted immune-associated cytokines. **Final presentation:** At the last day of the module, the students will give a scientific presentation and will defend and discuss the results of the practical course within the scientific context.
4	**Teaching methods** Lectures, practical course with demonstrations and hands-on guidance (everybody will have hands-on experience), oral presentation, supervised protocol writing and data analysis
5	**Prerequisites** **Formal:** Successful completion of module 1.

	With regards to content: basic knowledge of neurobiology
6	**Examination type:** cumulative examination Written exam covering lectures and practical course (70% of total grade) Scientific presentation (30% of total grade)
7	**Requirements for award of credit points** Regular participation in the practical training. Final presentation and discussion of experimental results. Successful participation in the written examination.
8	**Module applicability** (in other study courses) Master Biology
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lectures** Dr. R. Akkermann, Dr. K. Azim, Dr. N. Brazda, Dr. V. Estrada, Dr. P. Göttle, J. Gruchot, Prof. Dr. P. Küry, Prof. Dr. H.W. Müller, Dr. J. Schira
11	**Further information** The regular participation in the lectures is strongly recommended. The content of the lectures is prerequisite for the practicals and relevant for the written exam.

Module Number	Title:
3b	**Cellular and Molecular Analyses of Brain Function**

Module type: compulsory elective		**Language:** English	**Group Size:** 4 students
Study semester: 1	**Availability:** winter semester		**Duration:** 1 semester
Workload: 420 hrs	**Credits:** 14 CP	**Contact time:** 225 hrs	**Independent Study:** 195 hrs

1	**Courses** a) Practical course: 18 SWS b) Lectures: 2 SWS a) Seminar: 1 SWS
2	**Intended Learning Outcomes** The students are able to describe and apply the fundamental concepts and techniques of flu-orescence-based immunohistochemistry. They can use these concepts for the identification of various cell types and brain structures and make judgments regarding physiological and development-related questions. Students can use advanced techniques in light and fluorescence microscopy and adequately develop and evaluate the resulting documentation. They will know how to study basic physiological properties of brain cells using different techniques such as dynamic ion imaging and properly record, store, analyze, and illustrate the experimental data obtained with the specific techniques presented. They will learn to critically evaluate and interpret their experimental findings. They are able to give an informative overview of scientific questions, experimental design, results and interpretation of the performed experiments both in oral and in written form.
3	**Content** **Lecture: Molecular and cellular analyses of brain function** The basics of light microscopy: optics and lenses, structure of a microscope, optical path, aberrations, types of microscopes. Basics of fluorescence microscopy and immunohistochemistry. Fluorochromes, illumination, artifacts. Cell-type-specific labeling of neural cells with diagnostic antibodies. Brain development on the basis of selected brain regions (cortex, hippocampus, cerebellum). Maturation and function of neurons and glial cells in vertebrate brains and synapse formation. Molecular and cellular basis of neuronal and glial cell function, properties of glial cells and neuron-glia interaction, basic concepts of extra- and intracellular ion homeostasis, activity-related extra- and intracellular ion signaling (calcium, potassium, sodium, pH). Excitotoxicity and role of ion dysbalance in brain pathology. Glial cells as central elements in brain pathology. **Practical course: Immunohistochemistry and Physiology** *Immunohistochemistry:* Primary and secondary immunofluorescence, identification of neural cell types, determination of the maturation stages of glial cells and neurons, marking of functionally relevant membrane structures in neurons and glial cells. *Fluorescence microscopy*: Components of a light microscope, epifluorescence microscopy, confocal laser microscopy, camera-assisted documentation, image processing. Physiology: Preparation of acute tissue slices of the mouse brain, electrophysiological techniques in acute brain slices. Measurement of electrical signals under physiological conditions and their alteration under pathophysiological conditions.

	Intracellular, dynamic life imaging of intracellular ion signals under physiological and pathophysiological conditions (e. g. calcium imaging, sodium imaging and/or imaging of pH dynamics). Measurement of extracellular ion dynamics using on-selective microelectrodes. **Recommended reading, lecture notes:** Imaging in Neuroscience and Development: A Laboratory Manual. Cold Spring Harbor Laboratory Press Development of the Nervous System. Sanes, Reh & Harris, Elsevier 2012. Additional scripts and other documents will be available electronically through ILIAS.
4	**Teaching methods** Lecture, Practical course, Seminar
5	**Prerequisites** **Formal:** Successful completion of module 1; Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR) **With regards to content:** Knowledge of cell biology, chemistry, physics, mathematics as well as basic knowledge of neurobiology required.
6	**Examination types** **Cumulative examination:** 1. Written examination about the contents of the lecture (70% of overall mark), 2. Description of analyses by pictures and notes, performance of experiments and analysis (15% of overall mark) 3. Presentation: drafting of project, graphical description of project, presentation and discussion (15% of overall mark)
7	**Requirements for award of credit points** Regular attendance at the practical course. Successful completion of a course project. Oral presentation in a seminar with an accompanying written hand out. The final grade is calculated from the mark of the written exam (weigh 70% of final grade) and the description of analyses, performance of experiments and the presentation (weigh 30%).
8	**Module applicability (in other study courses)** M.Sc. Biologie M.Sc. Translational Neuroscience M.Sc. Molecular Biomedicine
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. C. R. Rose; M.Sc. N. Gerkau, Dr. K. Kafitz, Dr. C. Karus
11	**Further information** The regular attendance at the lectures is strongly recommended. The content of the lectures is prerequisite for the practical course and the seminar.

Module Number	**Title:**		
3c	**Cognitive Neurosciences**		
Module type: compulsory elective	**Language:** English		**Group Size:** 10 students
Study semester: 1	**Availability:** winter semester		**Duration:** 1 semester
Workload: 420 hrs	**Credits:** 14CP	**Contact time:** 119 hrs	**Independent Study:** 301 hrs

1 Courses

a) Lectures: 4 PPW
b) Practical Course: 5 PPW
c) Seminar 2 PPW

2 Intended Learning Outcomes

Upon completion of this module the students are able to describe the functioning of the human brain with respect to processes such as neural rhythms and oscillatory networks as well as systems such as control of movement, perception and emotions. They are capable to explain and interpret modern imaging methods for representing the structures and functions of the human brain as well as methods for brain stimulation. These include magnetic resonance imaging (MRI), neuroinformatic tools and models, magnetoencephalography (MEG), electroencephalography (EEG), transcranial magnetic stimulation (TMS), transcranial direct and alternating current stimulation (tDCS/tACS) and deep brain stimulation (DBS). The students will be able to plan, develop and apply experiments employing these methods (including first knowledge in applying them), to evaluate and interpret the data thus gathered and to coherently present the results verbally and in writing.

3 Content

Lecture: *Cognitive Neuroscience: from the brain to behaviour*
Methods of brain imaging and brain stimulation, neural rhythms and oscillatory networks, the motor system, control of movement and action planning, the somatosensory system and pain, perception and attention, memory systems, emotion and motivation, social neuroscience, neurological disorders.

Recommended reading:

- Baer, MF, Connors, BW, Paradiso MA: Neuroscience – Exploring the Brain. Lippincott Williams and Wilkins, USA 2007
- Squire LR, Berg D, Bloom FE, DuLac S, Ghosh A, Spitzer NC: Fundamental Neuroscience. Elsevier, Amsterdam 2008

Practical course: *Measurement and modulation of human brain activity*

1) *Theoretical exercises on imaging techniques and neurophysiological methods:* MEG and EEG (including planning, execution and evaluation of MEG and EEG examinations, derivation of eye movements and muscle activity, registration of movement kinematics, time frequency analyses, dipole analyses, co-registration of MRT and MEG), structural and functional MRI including morphometry, connectivity analysis and data-driven analyses, local field potential derivations from basal ganglion cores in patients with movement disorders, deep brain stimulation

2) *Experimental neurophysiological and functional imaging applications for the examination of brain functions as well as their non-invasive modulation:* Students will perform following methods in the practical course: Electroencephalography (EEG), trans-cranial magnetic stimulation (TMS), magnetencephalography (MEG), transcranial electric stimulation (tDCS, tACS) as well as the analysis of structural and functional magnetic resonance imaging data.

***3) Short presentation of experimental results at the end of the course*.**

Seminar: *Analysis and Organization of Cognitive Systems*
Functional neuroanatomy, brain network analysis, connectivity, motor and somatosensory systems, perception and attention, language, memory, emotion and motivation, social cognition.

4	**Teaching methods** Lecture, seminar and practical course with accompanying lessons
5	**Prerequisites** **Formal:** Successful completion of module 1. Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR); Bachelor degree in biology, psychology or a related field **With regards to content:** Basic knowledge of neuroanatomy, neurophysiology and neurobiology are a prerequisite.
6	**Examination types** **Cumulative Examination:** 1. Oral presentation (e.g. Powerpoint) in seminar (50% of total grade), 2. Poster presentation of experimental results at the end of the practical course incl. examination on lecture content (50% of total grade).
7	**Requirements for award of credit points** Regular and active participation in the lecture, practical course and seminar, including oral presentations in the latter. Drafting of experimental designs. Successful presentation of the project at the end of the practical course.
8	**Module applicability (in other study courses)**
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. S. B. Eickhoff, Dr. M. Butz, Dr. Robert Langner, Prof. Dr. Esther Florin
11	**Further information** The regular attendance at the lectures is strongly recommended. The content of the lectures (material presented both viva voce and on slides) is prerequisite for the practical course and the seminar, and will be examined as part of the oral presentation of experimental results at the end of the module.

Module Number	Title:
4a	**Experimental and Translational Neuroimaging**

Module type: compulsory elective	**Language:** English		**Group Size:** 12 students
Study semester: 2	**Availability:** summer semester		**Duration:** 1 semester
Workload: 240 hrs	**Credits:** 8 CP	**Contact time:** 75 hrs	**Independent Study:** 165 hrs

1	**Courses** a) Lecture 2 PPW b) Seminar: 1 PPW c) Practical block course: 3 PPW
2	**Intended Learning Outcomes** Upon completion of this module the students are capable to describe how neuroscientific questions can be adequately addressed by neuroimaging techniques and to identify the appropriate imaging technique for a specific question. The students will be able to apply commonly used neuroimaging techniques in biomedical research with regard to human and animal studies. After attending the seminar the students will be capable to describe the regulatory and ethical prerequisites for clinical and experimental studies and fundamental principles of neuroimaging techniques.
3	**Content** The practical course will cover the main topics of design, application, performance and documentation of neuroimaging studies as part of clinical trials with respect to their use as primary trials for novel diagnostic methods or as secondary read-outs for the efficacy of a therapeutic candidate. The students will learn about the theoretical background of imaging techniques, mainly magnet resonance imaging (MRI) and positron emission tomography (PET) and radiation protection. Hands-on training in a representative set of practical experiments will reinforce the theoretically acquired knowledge.
4	**Teaching methods** Block seminar and practical course
5	**Prerequisites** **Formal:** Successful completion of module 1. Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR) **With regards to content:** Participants who have a demonstrable focus on the area of neurosciences.
6	**Examination types** Written Exam
7	**Requirements for award of credit points** Attendance of the seminar and active participation in the exercises and hands-on training session, oral presentation and delivery of protocol, passing the written examination
8	**Module applicability (in other study courses)** None
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. Andreas Bauer, Dr. David Elmenhorst, Dr. Ali Gordjinejad, Dr. Andreas Matusch, Dr. Simone Beer, Dr. Tina Kroll
11	**Further information** Block seminar and practical course will be held at the Forschungszentrum Jülich. There will be a daily bus shuttle for participants between HHU and Forschungszentrum Jülich.

Module Number	Title:
4b	**Methods in Neurosciences**

Module type: compulsory elective	**Language:** English		**Group Size:** 6 students
Study semester: 1	**Availability:** summer semester		**Duration:** 1 semester
Workload: 240 hrs	**Credits:** 8 CP	**Contact time:** 69 hrs	**Independent Study:** 171 hrs

1 Courses

a) Lectures 2 PPW
b) Practical courses 4 PPW
c) Seminars 1 PPW

2 Intended Learning Outcomes

This module consists of three parts:
1. Testing locomotor behaviour of the rat
2. Histochemical technics for neuronal and glial characterization
3. Electrophysiology of neurons

After completion of the first part students will be able to describe the general principles in selected methods of locomotor and sensory tests for rodents. They are capable to quantitatively and critically evaluate its behavioural deficits and its outcome after nervous system injury and disease in comparison to the performance of intact animals.

After attending the second part students will be able to describe the cellular composition of the central nervous system with strong emphasis of developmental changes, cellular function and species differences addressing model species such as mouse and rat in comparison to higher primates and humans. They will be able to describe marker epitopes and their combinations, which will be characteristic for characterization of specific cells and the functional or pathophysiological state as a basis for their immunohistochemical identification. They will be capable to explain the production of epitope-specific antibodies. Students will be able to perform tissue preparation and to apply immunohistochemical staining techniques including the appropriate controls as well as microscopic evaluation of the results. They will be capable to present orally their experiments and test results to their peers.

After completion of the third part the students will be capable to explain the principles of electrophysiological recordings. They will be able to design and to perform electrophysiological experiments, to document and analyze their results and to summarize their findings in form of a scientific report.

3 Content

In the first part subjects to be dealt with:
1st week: Analysis of locomotor function of spinal cord injured and non-injured rats. General motor behaviour in the BBB open field test, evaluation of precise hind limb movement control and forelimb-hindlimb coordination in the horizontal ladder walking test, detailed automated gait analysis in the CatWalk® test, evaluation of test results.

In the second part students will be introduced to the principals of: Animal anesthesia and euthanasia. Hands on: Tissue dissection & preparation, tissue fixation methods, and methods for tissue embedding for light- or electron microscopy. The preparation of tissue sections (brain) and the preparation for immunohistochemistry, immunohistochemical staining techniques and final preparation of the tissue for microscopy including microscopical evaluation and data analysis.

	In the third part students will learn to record and to interpret single-unit and network neuronal activities in brain slices and primary cultures using microelectrodes and the patch-clamp technique. Action potentials, spontaneous synaptic activities, voltage- and ligand-gated ion channels will be studied. Neuronal identification will be performed with electrophysiological, pharmacological, immunohistochemical and molecular-biological (single-cell RT-PCR) methods. Transgenic mouse lines with a fluorescent reporter protein expressed under control of a cell-type specific promoter will be provided.
4	**Teaching methods** First part: Lectures, Seminars and Practical Course Second part: Lecture, hands-on training courses, Seminar Third part: Lecture and practical course
5	**Prerequisites** **Formal:** Successful completion of module 1. Bachelor in natural sciences; Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR); **With regards to content:** Participants who have a demonstrable focus on the area of neurosciences**.**
6	**Examination types** Written exam
7	**Requirements for award of credit points** Regular and active participation in seminars and practical courses. The written examination has to be passed.
8	**Module applicability (in other study courses)** Master Biology
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. Olga A. Sergeeva, Prof. Dr. H.W. Müller, Dr. Hans-J. Bidmon, Prof. Dr. Esther Florin, Dr. Veronica Estrada, Dr. Nicole Brazda
11	**Further information** A FELASA certificate is recommended and can be obtained by attending Module 2c "Laboratory Animal Course" in advance. The attendance at lectures is strongly recommended. The content is prerequisite for practicals and seminars.

Module Number	**Title:**		
5a	**Neuroimmunology**		
Module type: compulsory elective	**Language:** English		**Group Size:** 12 students
Study semester: 2	**Availability:** summer semester		**Duration:** 1 semester
Workload: 420 hrs	**Credits:** 14 CP	**Contact time:** 123 hrs	**Independent Study:** 297 hrs

1 Courses

a) Lectures 4 PPW
b) Practical Course 5 PPW
c) Seminar 2 PPW

2 Intended Learning Outcomes

After completion of this module the students are able to describe the immune system and its relevance to physiological and pathological conditions of the nervous system. The are able to define following terms: immune responses, blood brain barrier, antigen presentation, regulatory/effector immune cells, apoptosis, molecular mimicry, immunological diseases, autoimmunity, inflammatory conduction block.
They are capable to hypothesize on possible mechanisms involved in the development of neurological diseases and possible immunological therapy approaches.
They will be able to present a link between inflammation and degeneration and to summarize possible mechanisms of neuronal and glial damage in neuroinflammation and degeneration, comprising both primary and secondary neuroinflammatory diseases.

3 Content

Practical course

The module *Neuroimmunology* will cover the following topics:

1. Basics of immunology/regulation of the immune response
2. Chronic inflammatory disorders of the nervous system
3. Interactive exercises: animal models for autoimmune disorders of the central and the peripheral nervous system (CNS/PNS)
4. Interactions of immune cells and cells of the CNS and PNS: damage mechanisms and role of glia
5. Detection of inflammatory neurodegeneration *in situ* and *in vivo* (theory, preclinical animal experimental models + patient, imaging & optical coherence tomography & electrophysiology)

Students will perform the following methods during the practical course:
Immunology: Isolation and culture of immune cells from lymphatic organs and the nervous system. Investigation of immune cell function & phenotype (incl. multicolour flow cytometry, ^{3}[H] thymidine proliferation assays, cytokine ELISPOT & ELISA, migration assays). Induction of experimental disease in mouse and rat models of MS (experimental autoimmune encephalomyelitis/EAE), inflammatory neuropathies (experimental autoimmune neuropathy/EAN) and stroke (middle cerebral artery occlusion/MCAO). Investigation of immunological determinants in further neurological disorders such as brain ischemia
Neurobiology: Qualitative and quantitative histology and immunohistochemistry for major cell populations of the nervous system, including glia**.** Investigation of CNS neurogenesis *in vitro*, *in situ* and *ex vivo* considering the major neurogenic niches. Neurological (clinical) scoring of animals affected by chronic autoimmune disease. Electrophysiological examination of nervous system function. Detection of inflammatory neurodegeneration with PET and MR imaging as well as optical coherence tomography (OCT) *in vivo.* Living organotypic brain slices: preparation and comprehensive study by confocal microscopy, also using interaction models (co-culture of slices with immune cells).

4	**Teaching methods** Lectures with accompanying practicals with hands-on sessions and seminars
5	**Prerequisites** **Formal:** Successful completion of module 1. Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR) is requested. **With regard to content:**
6	**Examination types** Written exam
7	**Requirements for award of credit points** Participation in practical course and seminar, passing the final exam
8	**Module applicability (in other study courses)** Human medicine
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. med. Orhan Aktas, Prof. Dr. med. Norbert Goebels, Dr. rer. nat. Carsten Berndt
11	**Further information** A FELASA certificate is recommended and can be obtained by attending Module 2c "Laboratory Animal Course" in advance. The regular attendance at the lectures is strongly recommended. The content of the lectures is prerequisite for the practical course and the seminar.

Module Number	Title:
5c	**Systems Neurosciences**

Module type: compulsory elective		**Language:** English	**Group Size:** 8 students
Study semester: 1	**Availability:** summer semester		**Duration:** 1 semester
Workload: 420 hrs	**Credits:** 14 CP	**Contact time:** 105 hrs	**Independent Study:** 315 hrs

1 Courses

a) Lecture 3 PPW
b) Practical course 6 PPW
c) Seminar 2 PPW

2 Intended Learning Outcomes

The students are able to describe how behavioural states are organized on systemic, network-, cellular and molecular levels in relation to the daily circle. This includes sleep and waking, energy administration (temperature regulation, food intake and metabolism), and the release of hypothalamic hormones. The pathophysiology of these functions includes sleep disorders (e.g. narcolepsy, sleep apnoea), anorexia, obesity, central aspects of diabetes mellitus and neuroendocrine disorders. The students will be capable of observing behaviour, taking recordings from hypothalamic brain slices and primary cultures, performing neurotransmitter expression pattern analysis on brain sections, analysing receptor pharmacology and applying gene expression profiling. Students are capable to evaluate (data analysis), describe, interpret and document their experimental findings. They will demonstrate orally and in writing background, experimental approach, results and conclusions.

3 Content

Lectures:

Starting from basics in physiology and endocrinology we will explain the daily organization of behaviour, physiology and pathophysiology of sleep-waking and consciousness and discuss new methods allowing identification of responsible neuronal groups and circuitries with new perspectives for therapy. Specific topics: clock genes, the various aspects of circadian rhythms, circadian and homoeostatic regulation of behavioural state, wake- and/or sleep-active neurons, morphological and biochemical components of energy administration (temperature and body weight regulation, feeding). Neurotransmitters and modulators involved in these functions with their localisation, mainly in the hypothalamus, and signalling pathways (GABA, glutamate, biogenic amines and hypothalamic peptides), endogenous sleep-promoting agents (adenosine, melatonin). Mechanisms of action of general anaesthetics. Pathophysiology of sleep, neurodegenerative and metabolic diseases.

Practical course:

Students will perform the following methods:

1) (automatic) registration and analysis of behaviour (spontaneous locomotor activity).
2) preparation and use of primary cultures, recording with 60 channels in microelectrode arrays.
3) preparation of vital brain slices for electrophysiological recordings.
4) preparation of acutely isolated hypothalamic neurons, mRNA harvesting after patch-clamp recording, single-cell RT-PCR.
5) primer design, real-time RT-PCR
6) preparation of cryosections from mouse brains. Immunodetection of receptors and enzymes in neurons. Analysis of immunostainings with conventional and Laser Scanning Confocal Microscopy. In situ hybridization histochemistry including generation of digoxigenin-labeled riboprobes by in vitro transcription, hybridization and immunodetection followed by microscopic analysis.

Seminar:

Students give a presentation on selected seminal and recent papers of the field (oral presentation or e-poster presentation with projection).

Recommended reading:

	Saper CB “Staying awake for dinner: hypothalamic integration of sleep, feeding, and circadian rhythms” Prog Brain Res. 2006;153:243-52. Lin JS, Anaclet C, Sergeeva OA, Haas HL. (2011) The waking brain: an update. Cell. Mol. Life Sci 68:2499-512
4	**Teaching methods** Lecture/Seminar/Practical Course
5	**Prerequisites** **Formal:** Successful completion of module 1. Bachelor in the natural sciences or engineering or a medical degree. The animal course would be advantageous. Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR). **With regards to content:** focus on neuroscience, knowledge of neurobiology, chemistry, physics, mathematics.
6	**Examination types** Written examination
7	**Requirements for award of credit points** Regular attendance in the practical course and the seminar Delivery of a protocol (in the style of a scientific manuscript) Delivery of a presentation in the seminar Passing written examination at the end of the module
8	**Module applicability (in other study courses)** Master Biology (international) Master Biochemistry
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. Olga A. Sergeeva, Prof. Dr. Hans Reinke, Dr. Heike Heuer, Dr. Wiebke Fleischer, Dr. Tatsiana Suvorava
11	**Further information** The regular attendance at the lectures is strongly recommended. The content of the lectures is prerequisite for the practical course and the seminar.

Module Number	Title:
6	**Research Ethics and Technics**

Module type: compulsory		**Language:** English	**Group Size:** 20 student
Study semester: 2	**Availability:** summer semester		**Duration:** 1 semester
Workload: 240 hrs	**Credits:** 8 CP	**Contact time:** 68hrs	**Independent Study:** 172 hrs

1 Courses

a) Placement 4 PPW
b) Lecture 1 PPW
c) Seminar 1 PPW

2 Intended Learning Outcomes

This module consists of two parts: Research ethics and a 4-week lab rotation (part research technics).

The idea of an integrative module stems from the need for making the students duly aware of the practical (ethical and pragmatic) and theoretical dimensions of their own science, and of the non-trivial interactions between the two levels. The integration of the ethical module with the lab rotation should help by providing the students first-hand experience (in a relatively short time) of the many facets of neuroscientific research, as well as with the tensions and contradictions internal to the field.

The way science is conceptualized and practiced today has been shaped by historical developments, and neuroscience has complex ethical and social dimensions. In the research ethics part students should recognize and understand that science is a social and cultural activity.

After attending the research technics part the students should be able to independently carry out experiments with the technics they have learned during their stay in different laboratories (lab rotation). The type of technics learnt will depend on the working group.

Upon completion of the research ethics part the students will be able to describe the basics in philosophy of science, including the logic of science and the role of norms and values in science, the role of rhetoric language and metaphors in science, theoretical and historical foundations of neuroscience, models of reasoning in biomedical ethics and research ethics, with a special focus on research on humans and research data management (patient autonomy, record keeping, data protection and safety). They will be able to understand the “usefulness of useless knowledge” (Russel) and will be able to understand, analyse and present scholarly texts, critically reflect upon current research, including its historical, social, and ethical dimensions and test coherence and consistency of ethical arguments. They will be able to present these acquired skills in a reduced form in a poster format.

3 Content

Lectures and Seminars:

- Basics of biomedical ethics
- Critical history of the neurosciences
- Research ethics (focus on human subjects)
- Good scientific practice
- Current topics in neuroethics
- Neuroscience, Identity and “Free Will”
- Research data management

Practicals:

The lab rotation is a practical in different laboratories (lab rotation) to get profound

	insight into specific methodologies and scientific questions. After its completion, a summary of the experimental work is to be drawn up and to be presented orally during the faculty seminar of the working group. The methods learnt will depend on the working group.
4	**Teaching methods** Lecture, seminar with oral reports, group work, collective poster presentation
5	**Prerequisites** **Formal:** Successful completion of module 1. Depends on faculty or working group. **With regards to content:** Depends on faculty or working group.
6	**Examination types** Poster presentation: Poster (50% of overall mark) and individual oral presentation (50% of overall mark). A team of 2 - 4 students prepares in home work a poster (e-poster or printed in DIN A0) and presents the poster orally in minimum 10 and maximum 20 minutes during the last seminar sessions. The evaluation criteria for the oral poster presentation and content and lay out of the poster will be handed out at the beginning of the module.
7	**Requirements for award of credit points** Participation in the seminars and lab rotation. Presentation of own results/data gathered during the lab rotation in the institute´s seminar. A pass in the poster presentation. Return signed and filled in routing card to coordinator.
8	**Module applicability (in other study courses)**
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. Heiner Fangerau, Dr. Fabio de Sio, for the lab-rotation: variable
11	**Further information** Lab-Rotation: Register directly with the faculty/working group. Minimum stay per lab is 1 week. Return signed and filled in routing card to coordinator.

Module Number **PP1**	Title: **Pilot Project**		
Module type: compulsory		**Language:** English	**Group Size:** 20 students
Study semester: 3	**Availability:** winter semester		**Duration:** 12 weeks
Workload: 450 hrs	**Credits:** 15 CP	**Contact time:**	**Independent Study:**

1	**Courses** a) Placement b) Faculty Seminar c) Seminar Scientific Writing and Presenting 1 PPW
2	**Intended Learning Outcomes** The Pilot Project serves to illustrate research activities in a working group on a given experimental project. Students perform a 12-week placement in a working group. They are assigned to a specific experimental project on which they can work under one-to-one supervision. The ability of adequately reporting scientific results is supported by an accompanying seminar in scientific writing and presenting. After the completion of the module, the students should be able to independently perform the experiments carried out in the respective working groups. They are able to summarize their experimental work in writing and present it orally.
3	**Content** **Placement:** The content is variable and depends on the working group. **Faculty Seminar:** The experimental data of the assigned project is to be presented orally at the faculty seminar. **Seminar Scientific Writing and Presenting:** Introduction to preparing scientific publications (e.g. paper, poster) and oral presentations.
4	**Teaching methods** Practical course and seminar, lectures as part of faculty seminar, summary of experimental work
5	**Prerequisites** **Formal:** Depends on faculty or working group; Successful completion of modules no. 1 to 6. Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR) **With regards to content:**
6	**Examination types:** Oral presentation of experimental work
7	**Requirements for award of credit points** Regular participation in the placement and seminars, delivery of a written summary of experimental work, a pass in the module final exam.
8	**Module applicability (in other study courses)**
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**<u>Module convenor</u> and main lecturers** Seminar "Scientific Writing and Presenting": Studierendenakademie of HHU Düsseldorf Placement and Faculty Seminar: Variable
11	**Further information** Placement: Register directly with the faculty/working group. Return signed and filled in routing card to coordinator.

Module Number	Title:
PP2	**Project Proposal**

Module type: compulsory	**Language:** English	**Group Size:** 1 student (course a, b); 20 students (course c, d)

Study semester: 3	**Availability:** winter semester	**Duration:** 8 weeks

Workload: 450 hrs	**Credits:** 15 CP	**Contact time:**	**Independent Study:**

1 Courses

a) Placement
b) Faculty Seminar
c) Lecture Data Analysis 1 PPW
d) Practical Course Data Analysis 2 PPW

2 Intended Learning Outcomes

The project proposal serves as a preparatory exercise for the Master's thesis. Students perform an 8-week placement in a working group on an experimental project of their choice. After completion a project sketch for the Master's thesis is to be drawn up. Lectures and practicals in statistical analysis of high-dimensional data support the ability of the students to analyse their data.

After completing the module the students should be able to independently carry out a self-selected experimental project in the field of translational neuroscience. They are capable to draw up and present a written concept (project sketch) for the Master' s thesis. Upon completion of the data analysis part the students will be able to perform statistical analyses of high-dimensional data from neuroscience such as sequencing or structural and functional MRI data. The students will acquire knowledge on statistical and bioinformatic approaches, e.g., for preprocessing the data and for assessing the quality of the data as well as machine learning and statistical methods such as multiple testing procedures, clustering, discrimination and regression approaches, and principle component analysis. They will be able to decide which of these methods to use in which situation and to apply these procedures to the data.

3 Content

a) Placement:

Students perform an 8-week placement in a working group on a experimental project of their choice. The topic of the experimental work performed is variable and depends on faculty or working group.

b) Faculty Seminar:

The project is to be presented orally at the faculty seminar.

c) Lectures Data Analysis:

The course starts with a basic, practical introduction to the statistical software environment R, which is frequently used in the analysis of high-dimensional data. General statistical procedures such as multiple testing approaches, sampling methods (e.g., bootstrapping), clustering procedures (e.g., hierarchical clustering, k-means), discrimination methods (e.g., linear discriminant analysis, Random Forests, support vector machines), regression approaches (e.g., linear and generalized linear models), and dimension reduction procedures (e.g., principle component analysis) often used in the statistical analysis of high-dimensional data from neuroscience will be described, focussing on the practical aspects of these procedures. Moreover, procedures for preprocessing and quality control of data from, e.g., microarray, sequencing, and structural and functional MRI experiments in relation to genetic, environmental and

	performance data will be taught. Also more specific approaches for the different types of data will be discussed, e.g., procedures for calling variants or determining gene expression values in sequencing experiments. This last part of the data analysis course will be tailored to the specific needs of the current Master students and will allow them to ask specific questions concerning the statistical/bioinformatic aspects of their project proposal. **d) Practicals Data Analysis:** All methods taught in the data analysis lecture will be practized by the students by applying them to real high-dimensional data from different types of studies. If already available, the students can bring their own data and apply the procedures to these data during the practicals.
4	**Teaching methods** Practical course, lectures with accompanying exercises, project sketches, faculty seminar
5	**Prerequisites** **Formal:** Depends on faculty or working group; Successful completion of module "Pilot Project". Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR) **With regards to content:** Depends on faculty or working group.
6	**Examination types:** Written examination on data analysis
7	**Requirements for award of credit points** Participation in the placement and the faculty seminar, presentation of own results/data in the Faculty seminar and a concluding written project sketch for the Master's thesis, a pass in the module final exam. Return signed and filled in routing card to coordinator.
8	**Module applicability (in other study courses)**
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**<u>Module convenor</u> and main lecturers** a) and b) Variable c) and d) Prof. Dr. Holger Schwender
11	**Further information** Register directly with the faculty/working group for the placement. Return signed and filled in routing card to coordinator.

Module Number	**Title:**		
MT	**Master's Thesis**		
Module type: compulsory		**Language:** English	**Group size:** 1 student
Study semester: 4	**Availability:** summer semester		**Duration:** 1 semester
Workload: 900 hrs	**Credits:** 30 CP	**Contact time:**	**Independent study:**

1	**Courses** a) Placement a) Faculty seminar
2	**Intended Learning Outcomes** After completing the Master's thesis, the students should be able to independently carry out, summarize in writing and present orally an experimental project of significant novelty value.
3	**Content** The Master's thesis is an independent experimental work based on the project proposal. Students complete a six-month experimental working phase with compulsory participation in the faculty seminars. The experimental work is in the field of translational neuroscience and dependent on the working group.
4	**Teaching methods** Supervised independent experimental work in a lab, oral and written progress reports, final oral presentation (colloquium), practical course, project sketch
5	**Prerequisites** **Formal:** Successful completion of all previous modules (90 CPs have to be acquired); Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR) **With regards to content:** Depends on faculty or working group
6	**Examination types** Written Master's thesis (80% of overall mark) Final colloquium (20% of overall mark)
7	**Requirements for award of credit points** Participation in the faculty seminar, presentation of own results/data in the faculty seminar; delivery of written Master's thesis and colloquium about Master's thesis.
8	**Module applicability (in other study courses)**
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**<u>Module convenor</u> and main lecturers** Variable
11	**Further information** Register directly with the faculty/working group