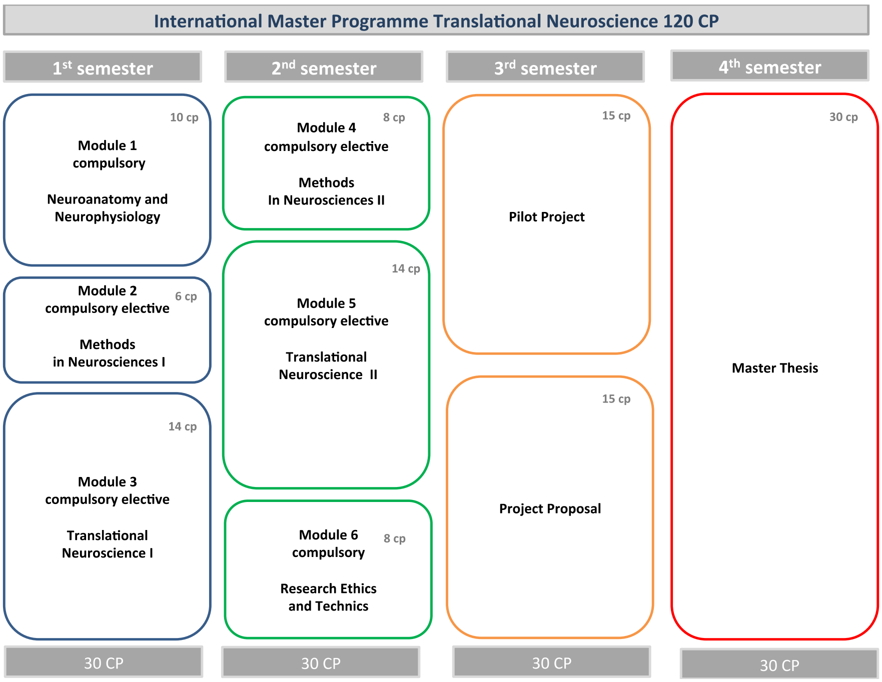
Module Handbook

Study Programme
Master of Science in
Translational Neuroscience

Date: Oktober 2023

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 3 (14 CP) compulsory elective: Translational Neuroscience I
- **Module 3a:** Modelling and regeneration of the nervous system: from animal models to iPSCs and brain organoids
- **Module 3b:** Analyses of Brain Function and Dysfunction
- **Module 3c:** Cognitive Neuroscience: Methods

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

Module 5 (14 CP) compulsory elective: Translational Neuroscience II
- **Module 5a:** Molecular Neuropathology
- **Module 5b**: Stem cell based brain organoids
- **Module 5c:** Methods in Neurosciences

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. 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: Methods
- 4a Experimental and Translational Neuroimaging
- 5c Methods in Neurosciences or alternatively 5a Neuroimmunology
- 6 Research Ethics and Technics

Regeneration of CNS Traumata:

- 1 Neuroanatomy and Neurophysiology
- 2c Laboratory Animal Course
- 3a Modelling and regeneration of the nervous system: from animal models to iPSCs and brain organoids
- 4b Systems Neurosciences or 4c Cognitive Neuroscience: Functional Systems
- 5a Molecular Neuropathology or 5b Stem cell based brain organoids
- 6 Research Ethics and Technics

Molecular Basis of Brain Development, Neurodegeneration and Disease:

- 1 Neuroanatomy and Neurophysiology
- 2b High-Throughput Analysis: Genomics and Proteomics or 2c Laboratory Animal Course
- 3a Modelling and regeneration of the nervous system: from animal models to iPSCs and brain organoids or 3b Analyses of Brain Function and Dysfunction
- 4b Systems Neurosciences or 4c Cognitive Neuroscience: Functional Systems
- 5a Molecular Neuropathology or 5b Stem cell based brain organoids or 5c Methods in Neurosciences
- 6 Research Ethics and Technics

During the first semester, there is an orientation tutorial in which you will receive all relevant information presented by two experienced students. As a rule, the orientation tutorial takes place weekly during the lecture period.

Module Number 1	**Title:** **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:** 86 hrs	**Independent Study:** 214 hrs

1	**Courses** a) Lectures 4 PPW b) Practical course 1 PPW c) Seminars 3 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; “Gray’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 (multiple-choice format) (108 minutes)

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)** Compulsory basic module, the completion of which is a prerequisite for enrolment in all other modules of the program. This module is not intended/suitable for use in other modules.
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. Ariane Bruno, Dr. Evelyn Oermann, PD Dr. Christina Herold, Dr. Kimberley Lothmann, Dr. Manuel Marx, Dr. Thomas Mühleisen, Apl-Prof. Dr. Nicola Palomero-Gallagher, Dr. Felix Ströckens, Dr. Martin Stacho, Prof. Dr. Christoph Fahlke, Prof. Dr. Sascha Weggen, 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 will be able to describe some of the physical concepts relevant to medicine, and identify their use in diagnostics and therapy. The students will be able to operate the laboratory equipment as described below, and connect the physical principles to the imaging techniques and technology.
3	**Content** **Lecture:** i. General introduction in physics of medical methods, from principle to functional details. While the introduction covers also aspects that are needed for general understanding, the core of the lecture is designed to serve as theoretical background for the practical course. ii. *Physics of x-Ray tomography*. x-ray production, x-ray absorption and scattering, x-ray detection. Image formation. iii. *Magnetic resonance*. Magnetic spins, Larmor frequency, spin resonance, spin interaction, contrast, electromagnetic induction. iv. *Magnetic resonance imaging.* Spin manipulation, spin relaxation, spin-echo and gradient echo imaging techniques. v. *Ultrasound imaging.* Production and propagation of ultrasounds, imaging, absorption and reflection of ultrasounds, image resolution. vi. Electrocardiography and electroencephalography. Production and transfer of electrical signals in the human body, physical interpretation of ECG and EEG. **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. Electrocardiography and electroencephalography. Measuring of own ECG, determination of the heart's electric axis. Measurements of EEG signal (or use of muster data) to determine brain activity triggered by strong factors. Independent component analysis of the EEG.
4	**Teaching methods** Lecture on the 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 teaching 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: 5** students
Study semester: 1	**Availability:** Each winter semester		**Duration:** 1 semester
Workload: 180 hrs	**Credits:** 6 CP	**Contact time:** 55 hrs	**Independent Study**: 125 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. Furthermore, they will be able to discuss the advantages and disadvantages of C. elegans as a model for neurodegenerative diseases.
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 / 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. Furthermore, the students will get insights into a neurotoxic C. elegans model and will learn how to prepare worm samples for downstream analysis.

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:** Basic knowledge of cell biology and biochemistry and Practical laboratory experience
6	**Examination types** Oral presentation (20 minutes)
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)** Modul 2b is more technically/analytically oriented. The focus is on state of the methods in genome/transcriptome sequencing and protein analysis as well as transcriptomics/proteomics quantitative approaches. Knowledge about these methods are helpful for several other modules dealing with cellular/animal systems and might also be relevant for the pilot projects/master's thesis. Parts of the module can also be used in other programs as currently in Master Molecular 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. Karl Köhrer, Prof. Dr. Kai Stühler, Dr. Gereon Poschmann, Dr. Patrick Petzsch, Prof. Dr. Anna von Mikecz, Thorsten Wachtmeister
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 3a	Title: Modelling and regeneration of the nervous system: from animal models to iPSCs and brain organoids		
Module type: compulsory elective	**Language:** English	**Group Size**: 6 students	
Study semester: 1	**Availability:** winter semester	**Study semester:** 1	
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, human induced pluripotent stem cells (iPSCs), and human iPSC-derived neural progenitor cells (NPCs), neurons, and brain organoids (2) will able to apply basic immunocytochemical techniques (using light and fluorescence microscopy) as well as qPCR measurements to identify and distinguish neural cell types (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 get an insight in mitochondrial homeostasis and energy metabolism, (6) will be able to work independently and accurately with laboratory equipment, (7) will be able to analyse and document experimental results according to good scientific practise standards, (8) 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; Introduction to Neuro- and gliogenesis, cell determination, differentiation and interaction; Microglial polarization and astroglial activation during development and disease; Molecular pathophysiology and regeneration: Multiple sclerosis, traumatic nerve injury and regeneration; Oligodendroglial cell differentiation and myelin repair; Pluripotent stem cells; Energy metabolism in stem cells and neurogenesis; Disease modelling of neurological mitochondrial diseases; High-content screenings; Mitochondria in stem cells and neurons; Brain mitochondrial diversity; Neuronal differentiation of human stem cells in 2D and 3D (brain organoids); Nuclear and mitochondrial genome editing; How to prepare a scientific manuscript. **Practical course:** The Küry lab 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; purification of precursor cells; 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 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; triggering astroglial cells; Immunoassay (ELISA) to detect secreted immune-associated cytokines. The Prigione lab belongs to the Department of General Pediatrics, Neonatology, and Pediatric Cardiology, at the University Clinic Düsseldorf (UKD) and will focus on human

	induced pluripotent stem cells (iPSCs) differentiated in 2D (neural progenitors and neurons) and 3D (brain organoids) to address changes in mitochondrial metabolism and in the context of disease modelling of neurological mitochondrial disorders. We will use the following sets of experiments: Cultivation of iPSCs, differentiation into neural progenitor cells (NPCs), neurons, and brain organoids, transfection of stem cells and neurons, DNA and RNA isolation for qPCR, cloning and CRISPR/Cas9 genome editing, Multi-electrode arrays (MEA), immunostaining of pluripotency and neuronal markers. **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 molecular neurobiology
6	**Examination type:** cumulative examination Written exam covering lectures and practical course (90 minutes, 70% of total grade) Scientific presentation (15 minutes, 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) The module is closely related to module 3b and 3d. The module is also used in Master Biology and Molecular Biomedicine (in combination with Module 3d).
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lectures** Dr. F. Bosse, Dr. P. Göttle, PD Dr. D. Kremer, MSc L. Reiche, MSc J. Gruchot, MSc Luisa Werner, Dr. Annika Zink, Prof. Dr. A. Prigione, Prof. Dr. P. Küry
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.

<table>
<tr><td>Module Number
3b</td><td colspan="3">Title:
Analyses of Brain Function and Dysfunction</td></tr>
<tr><td colspan="2">Module type: compulsory elective</td><td>Language: English</td><td>Group Size: 4 students</td></tr>
<tr><td colspan="2">Study semester: 1</td><td>Availability: winter semester</td><td>Duration: 1 semester</td></tr>
<tr><td>Workload:
420 hrs</td><td>Credits:
14 CP</td><td>Contact time:
225 hrs</td><td>Independent Study:
195 hrs</td></tr>
<tr><td>1</td><td colspan="3">Courses
a) Practical course: 8 SWS
b) Lectures and Workshop: 2 SWS
a) Seminar: 1 SWS</td></tr>
<tr><td>2</td><td colspan="3">Intended Learning Outcomes
The students are able to explain the basic structural properties of proteins and their implications in protein misfolding, protein aggregation and neurodegeneration. They can explain and apply biochemical and biophysical methods for characterization of proteins and their (mis)folding and aggregation. Students can handle basic laboratory instruments independently and appropriately. They document their results in a protocol and interpret them in relation to the scientific literature.
The students are able to describe and apply the fundamental concepts and techniques of fluorescence-based immunohistochemistry. They can use these concepts for the identification of various cell types and brain structures and make judgments regarding physiological and devel-opment-related questions. Students can use advanced techniques in light and fluorescence microscopy and adequately develop and evaluate the resulting documentation. They will learn to employ state of the art image analyses tools. 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. Students 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.</td></tr>
<tr><td>3</td><td colspan="3">Conent
(Physical Biology will cover 2 weeks; Neurobiology will cover 4 weeks of the course)
Lecture “Protein aggregation in neurodegenerative diseases”
Protein structure. Thermodynamics of protein folding. Protein misfolding and aggregation. Spectroscopy: Fluorescence and circular dichroism. The prion protein and prion diseases as an example for protein misfolding and seeding in neurodegeneration. Prion-like proteins in neurodegenerative diseases. Fundamentals of Alzheimer’s disease and Parkinson’s dis-ease. Mouse models of neurodegenerative diseases. Drug development for treatment of neurodegenerative diseases.
Lecture “Analysis of Brain Function and Dysfunction”
Development 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, extra- and intracellular ion signaling. Excitotoxicity and role of ion dysbalance in brain pathology and in brain ischemia. Glial cells as central elements in brain pathology.
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, artefacts. Cell-type-specific labeling of neural cells with diagnostic antibodies.
Workshop “Fluorescence microscopy and Imaging”
Basics of dynamic fluorescence imaging: Wide-field, confocal, multiphoton microscopy and FLIM. Superresolution microscopy: STED, SIM and PALM/STORM.</td></tr>
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	Imaging with ion-sensitive fluorescent dyes and genetically-expressed sensors, ion-sensitive microelectrodes. General lab work, use of eLab-FTW, statistical analysis, presentation of data. **Practical course:** **Physikalische Biologie: Seeding assays to elucidate pathological protein aggregation** *Protein aggregation assays:* Sample preparation of aggregation-prone proteins, fluorescence spectroscopy, CD spectroscopy, SDS-PAGE, design, execution and evaluation of seeding assays. *Cellular seeding assays:* Fundamentals of cell culture techniques, light and fluorescence microscopy, imaging, data acquisition, and analysis. **Neurobiology: Immunohistochemistry and Dynamic Cellular Imaging** *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. *Cellular Imaging:* 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 changes using ion-selective microelectrodes. *Analysis:* Data analysis of given data sets/own data sets, statistics, arrangement of data in figures and presentation. **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 (face to face and/or virtual), Workshop (face to face training and/or virtual), Practical course (hands on and virtual), Seminar (face to face and/or virtual)
5	**Prerequisites** **Formal:** Successful completion of module 1; Proficiency in English level B2 of Common Euro-pean 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 module including lectures, workshops and practical protocols and strategies (70% of overall mark), (2) Physikalische Biologie (10%): Experiment protocol (3) Neurobiology: Description of analyses by pictures and notes, performance of experiments and analysis (10% of overall mark) (4) Neurobiology: Presentation: drafting of project, graphical description of project, presentation and discussion (10% of overall mark)
7	**Requirements for award of credit points** Regular and active attendance at the practical course and virtual sessions. Successful completion of the practical courses. 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)** The module is closely related to module 3a, especially when using immunohistochemistry or -cytochemistry in combination with fluorescence microscopy. The module is also used in Master Biology and Master 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, Dr. K. Kafitz, Prof. Dr. Dieter Willbold, Prof. Dr. Wolfgang Hoyer, Dr. Luitgard Nagel-Steger, Prof. Dr. Erdem Gültekin Tamgüney
11	**Further information** The regular attendance at the lectures and workshop is strongly recommended. The content of the lectures is prerequisite for the practical course and the seminar.

Module Number 3c	**Title:** Cognitive Neuroscience: Methods		
Module type: compulsory elective	**Language:** English	**Group Size:** 12 students	
Study semester: 1	**Availability:** winter semester	**Study semester:** 1	
Workload: 420 hrs	**Credits:** 14CP	**Workload:** 420 hrs	**Credits:** 14CP

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 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 structural and functional magnetic resonance imaging (MRI), neuroinformatic tools and models, magnetoencephalography (MEG), and electroencephalography (EEG) as well as transcranial magnetic stimulation (TMS), transcranial direct and alternating current stimulation (tDCS/tACS), and deep brain stimulation (DBS). This is complemented by an introduction to statistics, computational modelling, neuroimaging meta-analysis, and lesion-based neuropsychological approaches. The students will be able to plan and develop investigations 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: *Methods in cognitive neuroscience: from brain to behaviour*
Methods of brain imaging and brain stimulation, neural rhythms and oscillatory networks, neuropsychology, statistical analysis approaches including a hands-on intro to Matlab
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 or EEG (including planning, execution and evaluation of MEG or EEG examinations, derivation of eye movements and muscle activity, time frequency analyses, co-registration of MRT and MEG, source reconstruction); structural and functional MRI (including morphometry, connectivity analyses, or coordinate-based meta-analysis).
2) *Experimental neurophysiological and functional imaging applications for the examination of brain functions as well as their non-invasive modulation:* Students will perform any of the following methods in the practical course: electroencephalography (EEG), transcranial magnetic stimulation (TMS), magnetoencephalography (MEG), transcranial electric stimulation (tDCS, tACS) as well as the analysis of structural or functional magnetic resonance imaging data.
3) Short presentation of experimental results at the end of the course.

Seminar: *Application of neuroscientific methods to the study of cognitive systems*
Functional neuroanatomy, brain network analysis, connectivity, event-related potentials, coherence analysis, neuropsychology, etc. applied to investigate motor and somatosensory systems, perception and attention, language, memory, emotion and motivation, social cognition.

	Students will present and critically discuss with the audience a paper exemplifying one of the above approaches and topics.
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 type:** **Cumulative Examination:** 1. Poster presentation of experimental results at the end of the practical course (15 minutes including questions, 33.3% of total grade). 2. Oral presentation and moderation of a discussion in the seminar (45 min, 33.3% of total grade) 3. Written exam (multiple-choice format) on lecture content (90 minutes, 33.3% 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. Written exam.
8	**Module applicability** The module is closely related to module 4c.
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. Simon Eickhoff, Prof. Dr. Esther Florin, PD Dr. Markus Butz, Dr. Robert Langner
11	**Further information** The regular attendance at the lectures is strongly recommended. The content of the lectures (material presented both via voice and on slides) is prerequisite for the practical course and the seminar, and will be examined in a written exam at the end of the module.

<table>
<tr><td colspan="2">Module Number
4a</td><td colspan="4">Title:
Experimental and Translational Neuroimaging</td></tr>
<tr><td colspan="3">Module type: compulsory elective</td><td colspan="2">Language: English</td><td>Group Size: 6 students</td></tr>
<tr><td colspan="3">Study semester: 2</td><td colspan="2">Availability: summer semester</td><td>Duration: 1 semester</td></tr>
<tr><td colspan="2">Workload:
240 hrs</td><td colspan="2">Credits:
8 CP</td><td>Contact time:
75 hrs</td><td>Independent Study:
165 hrs</td></tr>
<tr><td>1</td><td colspan="5">Courses
a) Lecture 2 PPW
b) Seminar: 1 PPW
c) Practical block course: 3 PPW</td></tr>
<tr><td>2</td><td colspan="5">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.</td></tr>
<tr><td>3</td><td colspan="5">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.</td></tr>
<tr><td>4</td><td colspan="5">Teaching methods
Block seminar and practical course</td></tr>
<tr><td>5</td><td colspan="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.</td></tr>
<tr><td>6</td><td colspan="5">Examination types
Written Exam (multiple choice, 63 minutes)</td></tr>
<tr><td>7</td><td colspan="5">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</td></tr>
<tr><td>8</td><td colspan="5">Module applicability (in other study courses)
The module is closely related to module 2a, 4c and 6.</td></tr>
<tr><td>9</td><td colspan="5">Assessment
The mark given will contribute to the final grade in proper relation to its credits.</td></tr>
<tr><td>10</td><td colspan="5"><u>Module convenor</u> and main lecturers
Prof. Dr. Andreas Bauer, <u>Dr. David Elmenhorst</u>, Dr. Ali Gordjinejad, Dr. Andreas Matusch, Dr. Simone Beer, Dr. Tina Kroll</td></tr>
<tr><td>11</td><td colspan="5">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.</td></tr>
</table>

<table>
<tr><td colspan="2">Module Number
4b</td><td colspan="3">Title:
Systems Neurosciences</td></tr>
<tr><td colspan="2">Module type: compulsory elective</td><td colspan="2">Language: English</td><td>Group Size: 6 students</td></tr>
<tr><td colspan="2">Study semester: 1</td><td colspan="2">Availability: summer semester</td><td>Duration: 1 semester</td></tr>
<tr><td colspan="2">Workload:
240 hrs</td><td>Credits:
8 CP</td><td>Contact time:
69 hrs</td><td>Independent Study:
171 hrs</td></tr>
<tr><td>1</td><td colspan="4">Courses
a) Lecture 2 PPW
b) Practical course 4 PPW
c) Seminar 1 PPW</td></tr>
<tr><td>2</td><td colspan="4">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.</td></tr>
<tr><td>3</td><td colspan="4">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) preparation of vital brain slices for electrophysiological recordings.
2) preparation and use of primary cultures, recording with 60 channels in microelectrode arrays.
3) preparation of acutely isolated hypothalamic neurons, mRNA harvesting after patch-clamp recording, single-cell RT-PCR.
4) primer design, real-time RT-PCR
5) preparation of cryosections from mouse brains. Immunodetection of receptors and enzymes in neurons. Analysis of immunostainings with conventional and Laser Scanning Confocal Microscopy.
Seminar:
Students give a presentation on selected seminal and recent papers of the field or progress report on experimental data from practical (Oral presentation e.g. Powerpoint).

Recommended reading:</td></tr>
</table>

	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** **Cumulative Examination:** 1. Oral presentation (e.g. Powerpoint) in seminar (45 minutes, 33.3% of total grade). 2. Written exam (multiple-choice format) on lecture content (90 minutes, 66.7% of total grade).
7	**Requirements for award of credit points** Regular attendance in the practical course and the seminar Delivery of a presentation in the seminar Passing written examination at the end of the module
8	**Module applicability (in other study courses)** The module is closely related to module 2a, 2b and 3b.
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. 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 4c	Title: Cognitive Neuroscience: Functional Systems		
Module type: compulsory elective	**Language:** English	**Module type:** compulsory elective	
Study semester: 2	**Availability:** summer semester	**Study semester:** 2	
Workload: 240 hrs	**Credits:** 8CP	**Workload:** 240 hrs	**Credits:** 8CP

1	**Courses** d) Lectures: 2 PPW e) Seminar: 1 PPW
2	**Intended learning outcomes** Upon completion of this module the students are able to describe the localization and functioning of a variety of important human brain systems that implement, for instance, the control of movement, perception, memory or emotions. They are capable to explain and interpret relevant phenomena, experimental paradigms and theoretical models as well as key findings pertaining to these functional systems. The students will be able to plan, develop, evaluate and interpret experiments and correlational studies on these brain systems, employing methods previously introduced in Module 3c.
3	**Content** **Lecture:** *Cognitive neuroscience: from brain to behaviour* Functional systems of the human brain: the motor system, control of movement and action planning, the somatosensory system and pain, perception and attention, memory systems, emotion and motivation, executive functions and decision-making, the language system, social neuroscience. This is complemented by an introduction to interindividual differences and psychometric assessment as well as select developmental and clinical aspects. **Recommended reading:** o Baer, MF, Connors, BW, Paradiso MA: Neuroscience – Exploring the Brain. Lippincott Williams and Wilkins, USA 2007 o Squire LR, Berg D, Bloom FE, DuLac S, Ghosh A, Spitzer NC: Fundamental Neuroscience. Elsevier, Amsterdam 2008 **Seminar:** *Analysis and organization of cognitive systems* Zooming in on particular functional systems of the brain in health and disease and empirical approaches to their investigation. Students will present and critically discuss with the audience a paper exemplifying one of the functional systems and an empirical approach to studying them.
4	**Teaching methods** Lecture and seminar
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 and neurophysiology are a prerequisite. Successful completion of module 3c (or equivalent knowledge about neuroscientific methods).

6	**Examination type:** **Cumulative Examination:** 1. Oral presentation (e.g. Powerpoint) and moderation of a discussion in seminar (45 minutes, 33.3% of total grade). 2. Written exam (multiple-choice format) on lecture content (90 minutes, 66.7% of total grade).
7	**Requirements for award of credit points** Regular and active participation in the lecture and seminar, including oral presentations in the latter.
8	**Module applicability** The module is closely related to module 3c.
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. Simon Eickhoff, Dr. Robert Langner
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) will be examined in a written exam at the end of the module.

Module Number **5a**	Title: **Molecular Neuropathology**		
Module type: compulsory elective	**Language:** English	**Module type:** compulsory elective	
Study semester: 2	**Availability:** summer semester	**Study semester:** 2	
Workload: 420 hrs	**Credits:** 14 CP	**Workload:** 420 hrs	**Credits:** 14 CP

1	**Courses** a) Lectures and/or Seminars 6 PPW b) Practical Course 5 PPW
2	**Intended Learning Outcomes** After completion of this module the students will be able to describe molecular mechanisms underlying diseases of the central nervous system, primarily related to neuroinflammation, neurodegeneration, and neoplastic transformation. The students will be familiar with the clinical symptoms and therapeutic options of such diseases, e.g. Multiple Sclerosis, Stroke, Alzheimer´s disease and brain tumors. They will be able to summarize possible mechanisms of neuronal and glial damage in neuroinflammation and age-associated neurodegeneration, to describe the origins of brain tumors and mechanisms of cellular transformation, and to present links between neuroinflammation, neurodegeneration and brain tumor development. The students will get an insight into clinical routine in the Department of Neurology. The students will be introduced to different systems (ranging from unicellular to multicellular model organisms) and techniques used to investigate neurological diseases at the molecular level. The students will be able to work accurately with laboratory equipment and to perform common laboratory methods in biochemistry, molecular and cell biology. The students will be able to analyse and document experimental results according to good scientific practice standards, and to present, discuss, and defend their experimental results.
3	**Content** **Lectures** The lectures will cover the clinical symptoms, therapy, and prevention of myasthenia gravis, stroke, multiple sclerosis, Alzheimer´s disease, and different forms of brain cancers. The molecular pathology and underlying mechanisms of the diseases (genetics, biochemical and cellular processes) will be discussed. Moreover, the lectures will provide general insights into basic immunology, cell death mechanisms, the aging process, protein folding and misfolding, stem cells in the brain. **Practical course** The students will perform experiments in the laboratories of the Department of Neurology, the Department of Neuropathology, and the Leibniz Research Institute for Environmental Medicine. Students will perform a variety of methods including the following during the practical course: Isolation and culture of primary cells and eukaryotic cell lines; differentiation of cells; migration assays; phagocytosis assays; pharmacological manipulation of cells and C. elegans; extraction and quantification of cellular proteins, SDS-PAGE and Western blotting; ELISA quantification of proteins; quantitative real-time PCR; immunohistochemistry and fluorescence microscopy; FACS analysis; recombinant expression of proteins and their purification; induction of stroke via photothrombosis; optical coherence tomography; *in vivo* behavioral assays to investigate age-associated neurodegenerative disorders in *C. elegans.*
4	**Teaching methods** Lectures with accompanying practicals including 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 (120 minutes)
7	**Requirements for award of credit points** Participation in practical courses and seminars, passing the final exam
8	**Module applicability (in other study courses)** The module is also used for the study program of 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, PD Dr. rer. nat. Carsten Berndt, Dr. rer. nat. Michael Dietrich, Dr. med. Michael Gliem, Dr. med. Jens Ingwersen, Dr. rer. nat. Gabriel Leprivier, PD Dr. med. Nico Melzer, Dr. rer. nat. Tim Prozorovski, PD Dr. med. Tobias Ruck, Prof. Dr. rer. nat. Sascha Weggen, PD PhD MD Natascia Ventura
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:		
5b	**Stem cell based brain organoids**		
Module type: compulsory elective	**Language:** English		**Group Size:** 10 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 SWS
b) Seminar: 2 SWS
c) Practical course: 5 SWS

2 Intended learning outcomes

After completion of this module, students will be familiar with

1. Knowledge on stem cells, pluripotent and induced pluripotent stem cells (iPSCs)
2. 3D *in vitro* models such as human brain organoids
3. Theoretical knowledge on iPSCs and brain organoid generation
4. Principles of neural stem cell biology
5. Theoretical knowledge on brain development and disease modelling using human brain organoids
6. Cellular organelles regulating neural stem cells proliferation and differentiation
7. Handling and culturing of neural stem cells
8. Immunostaining and imaging of stem cells including cancer stem cells
9. Sectioning of human brain organoids, immunostaining and high resolution imaging

3 Content

Lectures:

Historical aspects in development of in vitro models to study human brain development and disorder. Introduction to pluripotent and induced pluripotent stem cells (iPSCs). Generation of iPSCs. Characterization of iPSCs. Generation of human brain organoids. Trends and challenges in human organoids research. Modelling human brain development and modelling neurodevelopmental disorders. Cellular organelles regulating neural stem cell homeostasis. Principles in symmetric and asymmetric cell divisions. Disease modelling of rare disorders. Imaging methodologies.

Practical courses:

Introductions to light microscopy and image analysis. Microscopic examinations of iPSCs and iPSC-derived neural stem cells. Analysis of neural stem cells with various markers. Introduction to culturing iPSCs, neural stem cells and cancer stem cells. Analysis of cellular organelles and their dynamics. Chemical compounds treatments that target cancer stem cells. Introductions to brain organoids handling, imaging and analysis. Image processing and analysis.

Seminar: Short presentation of experimental results at the end of the course and/or presentation of selected scientific papers on the relevant topic. Each participating student will be instructed about the content of the presentation.

4 Teaching methods

Lectures on general topics of developmental neurobiology, stem cells and brain organoids. Seminar and practical courses with accompanying lessons.

5 Prerequisites

With regards to content:

Basic knowledge of microscopy, cell biology and neurobiology

6	**Examination type:** 1. Presentation (power point / chalk talk) (15 minutes, 50 % of total grade) 2. Written examination (60 minutes, 50 % of total grade)
7	**Requirements for award of credit points** Regular and active participation during seminars and practical courses; passing the oral examination prior to each experiment; submission of a report (electronically); final presentation and discussion of experimental results; passing the written examination
8	**Module applicability** None
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lectures** Prof. Jay Gopalakrishnan, Dr. Anand Ramani, Dr. Arul Mariappan and Dr. Elke Gabriel
11	**Further information** The regular participation in the lectures is strongly recommended. The content of the lectures is prerequisite for the practical and relevant for the written exam.

Module Number 5c	Title: Methods in Neurosciences		
Module type: compulsory elective	**Language:** English		**Group Size:** 6 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 3 PPW b) Practical courses 6 PPW c) Seminars 2 PPW
2	**Intended Learning Outcomes** This module consists of three parts: 1. Animal models of human disease 2. Comparative anatomy and histochemical techniques 3. Electrophysiology In the first part we will introduce in vitro and in vivo models of diseases (using vertebrate and invertebrate species) and appropriate methods for their analysis with the focus on spinal cord injury, status epilepticus, hepatic encephalopathy, Alzheimer´s and Parkinson´s Diseases. The nematode C.elegans as a model organism to study neuropathologies, such as alpha-synucleinopathy, will be used in the practical. After completion of the first part, students will be able to describe the general principles of selected methods to investigate locomotor activity (e.g. CatWalk, open field, rotarod) and cognitive abilities (e.g. water maze) of the rodents as well as locomotor and sensory activity of the nematode C. elegans. They will be capable to evaluate behavioural deficits associated with nervous system diseases documenting and analysing experimental results. Methods and data will be presented as a progress report. In the second part of the module, students will be introduced in comparative vertebrate anatomy, with a focus on the dopaminergic system. They will acquire knowledge about major neuroanatomical similarities and differences between the different vertebrate clades and learn about non-standard model species. In the practical part, students will learn to obtain and preserve brain tissue and to use several staining methods to label components of the nervous system. After completion of the second part, students will be able to describe the macroscopic brain layout of the different vertebrate clades and will have understood major evolutionary changes in vertebrate brain structures, the cellular composition of the central nervous system and the structures of the dopaminergic system in mammals and birds. Students will be able to perform brain extractions, tissue fixation, different staining techniques and analysis of brain slices with light and electron microscopy. They will be able to present orally their experimental data and/or one of the seminal papers, discuss the presented data and to identify and plan follow up experiments. 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 analyse their results and to summarize their findings in form of a scientific report.
3	**Content** In the first part different methods for in vivo and in vitro models of brain disorders will be introduced in lectures and seminars. Methods to study locomotor and sensory deficits in the nematode C.elegans will be explored in wild type and transgenic animals overexpressing human alpha-synuclein in dopaminergic neurons. In the second part students will be introduced to and perform the following techniques:

	animal anaesthesia and euthanasia, transcardial perfusion, tissue dissection & preparation, tissue fixation methods, different tissue cutting techniques, methods for tissue embedding for light- or electron microscopy, immunohistochemical staining and classic histological stainings. Furthermore, students will use light, fluorescence and electron microscopy to analyse and make pictures of their slices. In the third part students will learn to record and to interpret single-unit and network neuronal activities in rodent brain slices and primary cultures using microelectrodes and the patch-clamp technique. Human brain electrophysiological data analysis will be performed and discussed. Field potentials, 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. Modelling of ligand-receptor interactions, molecular dynamics and macroscopic currents of ion channels will be performed with *in silico* electrophysiology computational methods.
4	**Teaching methods** Lectures, Seminars and Practical courses
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 have a demonstrable focus on the area of neurosciences**.**
6	**Examination types** Written exam (90 minutes)
7	**Requirements for award of credit points** Regular and active participation in seminars and practical courses. Delivery of oral presentations (e.g. Powerpoint) of selected seminal papers and progress reports on experimental data. The written examination has to be passed.
8	**Module applicability (in other study courses)** The module is closely related to module 3a, 3c, 3d and 4c. Participants of Module 4b should not take Module 5c.
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, Dr. Felix Ströckens, Prof. Dr. Esther Florin, Prof. Alfonso-Prieto, PD PhD MD Natascia Ventura
11	**Further information** The FELASA certificate, which can be obtained by attending Module 2c, is required for students who would like to practice anaesthesia and transcardial perfusion themselves (otherwise, the techniques will only be demonstrated by the supervisor). The attendance at lectures is strongly recommended. The content is prerequisite for practicals and seminars.

Module Number 6	Title: **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 (on animal and human subjects)
- International and national bioethical guidelines
- Waste and attrition in translational research
- Current topics in neuroethics
- Neuroscience, Identity and “Free Will”

	Practicals: The lab rotation is a practical in different laboratories (lab rotation) to get profound insight into specific methodologies and scientific questions. The practical part is independent of the research ethics part by Prof. Fangerau. After its completion, a summary of the experimental work is to be drawn up in the working group. The extent of the summary depends on the respective working group and will not be graded. 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 of research ethics part (30 minutes): Poster (50% of overall mark) and individual oral presentation (50% of overall mark).
7	**Requirements for award of credit points** Participation in the seminars and lab rotation. A pass in the poster presentation of research ethics part. Presentation of own results/data gathered during the lab rotation in the institute´s seminar is optional. Return signed and filled in routing card to coordinator.
8	**Module applicability (in other study courses)** The module is compulsory and teaches contents in ethics. The lab rotation should give an insight into different laboratories.
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 (450h)
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 (30 minutes)
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)** None
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Seminar "Scientific Writing and Presenting": PD Dr. Christina Herold 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.

<table>
<tr><td colspan="2">Module Number
PP2</td><td colspan="4">Title:
Project Proposal</td></tr>
<tr><td colspan="3">Module type: compulsory</td><td colspan="2">Language:
English</td><td>Group Size:
1 student (course a, b);
20 students (course c, d)</td></tr>
<tr><td colspan="2">Study semester: 3</td><td colspan="3">Availability: winter semester</td><td>Duration: 8 weeks</td></tr>
<tr><td colspan="2">Workload:
450 hrs</td><td>Credits:
15 CP</td><td colspan="2">Contact time:</td><td>Independent Study:</td></tr>
<tr><td>1</td><td colspan="5">Courses
a) Placement
b) Faculty Seminar
c) Lecture Data Analysis 1 PPW
d) Practical Course Data Analysis 2 PPW</td></tr>
<tr><td>2</td><td colspan="5">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 data analysis support the ability of the students to statistically 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 different types of medical and biological data and to employ the statistical software R for these data analyses. The students will acquire knowledge on statistical methods such as testing procedures, analysis of variance, and regression approaches, on how to use these methods for a statistical data analysis, as well as on good practice in planning a study, preparing data sets for a statistical analysis, and presenting the results of such analyses. They will be able to decide which of these methods to use in which situation and to apply these procedures to the data.</td></tr>
<tr><td>3</td><td colspan="5">Content
a) Placement:
Students perform an 8-week placement in a working group on an 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 the most popular, advanced software for statistical data analysis. This knowledge on R is successively extended during the course. It is discussed how graphics and descriptive statistics can be generated in R and should be generated in general to present and summarise the data and the results of a data analysis in a best practice way. General statistical procedures such as testing approaches, multiple testing methods, analysis of variance, and regression approaches (e.g., linear and generalized linear models) often used in the statistical analysis of medical, biological, and genetic data are described, focussing on the practical aspects of these procedures. Moreover, good practice in planning a study as well as in preparing a data set for a statistical analysis in, e.g., R is discussed. The last part of the data analysis course is tailored to the specific needs of the current Master students and</td></tr>
</table>

	allows them to ask specific questions concerning the statistical aspects of their project proposal. **d) Practicals Data Analysis:** All methods taught in the data analysis lecture are practised by the students by applying them, in particular, in R to 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 (60 minutes)
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)** None
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.

<table>
<tr><td colspan="2">Module Number
MT</td><td colspan="4">Title:
Master’s Thesis</td></tr>
<tr><td colspan="3">Module type: compulsory</td><td colspan="2">Language: English</td><td>Group size: 1 student</td></tr>
<tr><td colspan="2">Study semester: 4</td><td colspan="3">Availability: summer semester</td><td>Duration: 1 semester</td></tr>
<tr><td colspan="2">Workload:
900 hrs</td><td colspan="2">Credits:
30 CP</td><td>Contact time:</td><td>Independent study:</td></tr>
<tr><td>1</td><td colspan="5">Courses
a) Placement
a) Faculty seminar</td></tr>
<tr><td>2</td><td colspan="5">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.</td></tr>
<tr><td>3</td><td colspan="5">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.</td></tr>
<tr><td>4</td><td colspan="5">Teaching methods
Supervised independent experimental work in a lab, oral and written progress reports, final oral presentation (colloquium), practical course, project sketch</td></tr>
<tr><td>5</td><td colspan="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</td></tr>
<tr><td>6</td><td colspan="5">Examination types
Written Master’s thesis (50 – 80 pages, 80% of overall mark)
Final colloquium (30 minutes, 20% of overall mark)</td></tr>
<tr><td>7</td><td colspan="5">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.</td></tr>
<tr><td>8</td><td colspan="5">Module applicability (in other study courses)
None</td></tr>
<tr><td>9</td><td colspan="5">Assessment
The mark given will contribute to the final grade in proper relation to its credits.</td></tr>
<tr><td>10</td><td colspan="5"><u>Module convenor</u> and main lecturers
Variable</td></tr>
<tr><td>11</td><td colspan="5">Further information
Register directly with the faculty/working group</td></tr>
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