# Interdiscilinary course catalogue for the master study program Neuroscience

The Interdisciplinary Course Catalog lists individual courses offered in the Master of Neurocience program, including course instructors, descriptions of course contents and qualification goals. Courses are grouped according to lectures, seminars and excercise courses.

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# Lectures, Seminars, Practical courses

# Winter term & Summer term

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| **Title** | Seminar: From genes to behavior |
| **Content** | How do genes define the behavior of humans and animals? Based on this question, we will explore examples that link the function of single genes to the behavior of an organism. These behaviors include mating behavior, individual personality and learning. One research paper from primary literature is assigned to each student. Using additional literature and feedback from the instructor, students prepare a 30-minute oral presentation on their topic and present it in front of an audience. |
| **Learning outcomes** | Students will get an overview of various topics from the field, as well as the basis of genetic and behavioral analysis. They will gain insight into methodology and the practical aspects of various different model organisms. Furthermore, they will learn how to present and structure scientific data, as well as how to critically discuss it with their audience. |
| **Responsible contact** | Bräcker, Lasse |

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|---|---|
| **Title** | Seminar: Current topics in Statistical Genomics |
| **Content** | In the seminar, the students critically present and discuss current publications related to genomic analyses. This includes papers related to experimental and computational aspects of single-cell RNA-sequencing, evolutionary genomics or cancer genomics that are relevant int the context of current Research of the AG Enard and AG Hellmann. |
| **Learning outcomes** | The students will be able to extract and judge relevant information also from complex literature and to exchange information and ideas on a scientific level with experts in Genomics. |
| **Responsible contact** | Enard, Wolfgang |

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| **Title** | Seminar: Animal Models for Psychiatric Disorders |
| **Content** | In the seminar, the students critically discuss the use and applications for animal models for psychiatric disorders, with a special focus on major depression and anxiety-related disorders. The students learn which approaches for translational psychiatry are state-of-the-art, which model systems are used and which molecular and behavioral readouts are applied to study psychiatric disorders. |
| **Learning outcomes** | Using examples from the recent literature, the students learn how to read and judge a scientific paper and how to summarize the key findings in a scientific presentation. The implications of different scientific approaches using animal models are discussed. Furthermore, the students learn to collect the diverse information on a specific topic related to the overall theme of the seminar and to compose a written assay about this. |
| **Responsible contact** | Schmidt, Matthias |

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|---|---|
| **Title** | Seminar: Advanced Seminar in Audio Information Processing |
| **Content** | The seminar is targeted at advanced students, PhD candidates and post-docs in the field of audio-information processing. Scientific publications on current topics in audio-information processing are presented in a small group and discussed in depth ("journal club"). Each participant will present publications on one occasion and lead the discussion. To prepare for the discussion each participant will read the material prior to each seminar meeting. |
| **Learning outcomes** | The focus of the seminar is on understanding and discussing the content. Participants get to know current topics in audio-information processing, train the comprehension of English-language scientific publications and practice scientific discourse as well as leading. |
| **Responsible contact** | Seeber, Bernhard |

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|---|---|
| **Title** | Seminar: Spatial and Temporal Cognition: Experiments and Models |
| **Content** | The seminar is a designed as a journal club. Every |

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| | week we read and discuss one paper related to spatial and temporal cognition. We pay particular attention to understanding the paper rather than embedding it into a big framework which needs a lot of background and expert knowledge. The specific focus and the papers change every semester. In general, we try to put together reading lists with recent articles on the specific topic of the semester, covering the spectrum from animal and human behavior to brain recordings and mathematical modeling.<br><br>The seminar is open to all interested students. We do not require specific (computational) neuroscience background. And we should have enough time to discuss and explain each other the used approaches and techniques as well as the key results and their interpretation. However, the level of the seminar varies over semesters depending on the people attending. |
| **Learning outcomes** | Participants get a glimpse of the broad field of spatial and temporal cognition and its neural basis. They get to know about recent concepts and ideas in the field as well experimental and computational techniques. Furthermore, they learn how to read and understand scientific papers. |
| **Responsible contact** | Thurley, Kay |

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|---|---|
| **Title** | Excercise: Extra- and Intracellular recordings of single and multi-units |
| **Content** | The course is intended for Master and PhD students interested in system neuroscience using a neurophysiological approach. |
| **Learning outcomes** | This course will teach the design, approach and basic analysis of extra and intracellular recordings of single and multi-units using semi-intact in vitro preparations of Xenopus larvae at different developmental stages. |
| **Responsible contact** | Straka, Hans |

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| **Title** | Excercise: Functional Organization of Vestibulo-Motor Responses |
| **Content** | The course is intended for Master and PhD students interested in the basic functional organization of gaze stabilization during active and passive body |

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| | movements. |
| **Learning outcomes** | The vestibulo-ocular reflex (VOR) will be studied in Xenopus larvae at different developmental stages, which allows investigating the ontogenetic plasticity. Using a combination of various methods including extracellular (single- and multi-unit) and intracellular recordings, anatomical tract tracing, and behavioral essays, the course gives an introduction into cellular aspects of sensory-motor transformation within the VOR circuitry. |
| **Responsible contact** | Straka, Hans |

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|---|---|
| **Title** | Excercise: Lecture and Practical Course in Neuroprosthetics |
| **Content** | The lecture covers the theoretical foundations of neuroprostheses.<br><br>As the underlying principle of all neuroprostheses is the electrical excitation of neurons, we will cover this topic in depth using cochlea implants as an example.<br><br>In the practical computer laboratory (2SWS), which complements the lecture (2SWS), we will program a solver for the cable equation of an active axon and implement a computer model of a cochlea implant. |
| **Learning outcomes** | Topcis:<br>- Overview neuroimplants<br>- numerical solution of linear and nonlinear differential equations<br>- electrical models of cells and neurons<br>- derivation and solution of the cable equation for nerve fibers (axons)<br>- simulation of the electrical excitation of nerve fibers (axons)<br>- simulation of electrical field spread in the body<br>- anatomy and function of the hearing organ<br>- coding of sound in the auditory nerve<br>- implementation of a coding strategy for a cochlear implant<br>- electrochemistry of electrodes, biocompatibility and foreign body reactions |
| **Responsible contact** | Hemmert, Werner |

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|---|---|
| **Title** | Excercise: Bio-Inspired Information Processing |
| **Content** | Possible topics:<br>- development of models of biological senses<br>- models of neuronal processing of sensory information<br>- measurement of bio-electrical signals<br>- electrophysiological measurements (multi-electrode array)<br>- electrical and optical stimulation of neurons |
| **Learning outcomes** | Implementation of bio-inspired processing for technical applications. |
| **Responsible contact** | Hemmert, Werner |

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|---|---|
| **Title** | Excercise: Neuroimmunological methods in experimental stroke research |
| **Content** | This student course provides a theoretical and practical insight in the broad field of immunology after stroke. Lectures about different aspects of immunology after stroke (e.g. neuroinflammation versus peripheral inflammation) provide an overview of the recent stroke research. The duration of the student course is one week, half a day lectures and half a day hands on work. No special qualifications are required. Wet lab experience is beneficial but not mandatory. |
| **Learning outcomes** | State of the art methodology, like flow cytometry and quantitative real-time PCR, will be introduced theoretically and later on used hands-on at the bench. |
| **Responsible contact** | Liesz, Arthur |

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| **Title** | Excercise: Molecular Neurogenetics and Experimental Stroke Research |
| **Content** | This course provides a theoretical and practical insight in Molecular Neurogenetics after stroke. Course content is selected from the following topics: SNP genotyping, cell transfection, real-time PCR, Western blotting, transcription assays, experimental mouse stroke models, immunohistochemistry, fluorescent microscopy |
| **Learning outcomes** | Students will get an overview of methodology and practical aspects of various molecular and neurogenetic lab procedures. |
| **Responsible contact** | Paquet, Dominik |

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|---|---|
| **Title** | ExcerciseMultichannel extracellular recordings in awake behaving rodents: from experiment to data analysis |
| **Content** | The course is intended for Master and PhD students interested in systems neuroscience and willing to learn state-of-the-art extracellular recording techniques. The course includes both theoretical introduction into all the aspects of the extracellular recording and hands-on practicum on recordings with tetrodes and silicon probes of local field potentials and multiple single neurons in freely moving rats. |
| **Learning outcomes** | Training will include rodent surgery, recording in typical behavioral tasks, data processing, spike sorting and typical data analysis in Matlab. Based on self-acquired data students will learn about application of the technique to spatial navigation and learning research, awake behavior and sleep, oscillations and population coding. |
| **Responsible contact** | Resnik, Evgeny |

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| **Title** | Excercise: Introduction into the Basics of Electrophysiological Recording Techniques: Theory and Application |
| **Content** | Possible topics:<br>- development of models of biological senses<br>- models of neuronal processing of sensory information<br>- measurement of bio-electrical signals<br>- electrophysiological measurements (multi-electrode array)<br>- electrical and optical stimulation |
| **Learning outcomes** | The participants will be involved in experiments, in which whole-cell patch-clamp recordings, electrical and optogentic stimulation, micro-iontophoresis, etc. will be applied in vitro. In addition, neurographical recordings of human bioelectrical signals (spontaneous EMG and evoked motor potentials) will be performed. |
| **Responsible contact** | Riedemann, Therese |

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| **Title** | Excercise: Analysis of multichannel extracellular recordings and optogenetic manipulations in the visual cortex of awake mice |
| **Content** | Building on theoretical neuroscience courses on the Master's level, the module aims to provide practical experience in in vivo extracellular recordings and optogenetic manipulations, in addition to exposing students to principles of professional data management and data analysis methods. The first week consists of data acquisition and processing, such as spike sorting, the second week deals with data analysis in Python and histology. |
| **Learning outcomes** | Students obtain an overview of the steps necessary to perform electrophysiological recordings in the visual system of awake mice and circuit manipulation with optogenetics. The practical course will provide students with background knowledge on how to map and analyze visual response properties. They will also develop a deeper understanding of data management in scientific settings, being exposed to relational databases, version control of code, and principles of programming in Python. |

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| **Title** | Seminar: Current Topics in Neural Circuits of Vision |
| **Content** | Building on more general neuroscience courses on the Master's level, the module aims to significantly deepen and expand knowledge and understanding of neural circuits in the visual system. Recent, high-impact original papers are discussed that fit to the topics of microcircuits in visual cortex, feedforward and feedback processing, the dynamic interplay between excitation and inhibition, and the role of these circuits for visual behaviour. An emphasis is put on quantitative analysis methods, including computational model approaches. |
| **Learning outcomes** | Students obtain specialised knowledge in visual neuroscience required to participate in practical experiments and further specialised courses. Students will be prepared for discussions with experts in the field. The students will be able to integrate their basic knowledge on neuronal circuit function and behavior, and deal with the complexity of Neuroscience. The seminar will also provide students with knowledge on how to critically evaluate published findings. |
| **Responsible contact** | Busse, Laura |

## Winter Term

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| **Title** | Lecture: Human genomics |
| **Content** | This lecture builds on knowledge obtained in molecular biology and genetics on the Bachelor's level. It aims to deepen an understanding how the human genome was sequenced and annotated and how it is currently used to study human biology in health and disease. The following topics are addressed: The human genome project, high throughput sequencing technologies, basics in sequence analysis, gene annotation, gene expression analysis. |
| **Learning outcomes** | The students will be able to describe and understand fundamental principles of human genomic research. They will acquire the basic background knowledge to apply genomic technologies. |
| **Responsible contact** | Enard, Wolfgang |

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| **Title** | Lecture: Mechanism of Animal Development: Invertebrate Models |
| **Content** | This course covers fundamental mechanisms of animal development, as determined using the model invertebrates, Drosophila melanogaster and Caenorhabditis elegans. Basic principles are discussed, as are the experimental methodologies that have led to key discoveries. The lecture is given weekly (2 SWS) and requires regular attendance and a final exam. |
| **Learning outcomes** | The students are proficient in the basic developmental biology (embryology and fate maps) of Drosophila and C. elegans.<br><br>Students are familiar with the genetic, molecular, and experimental methods used to elucidate principles of development.<br><br>Students are able to interpret novel data sets, formulate hypotheses, and suggest experimental approaches that could be used to test these hypotheses.<br><br>Students are able to integrate knowledge from lecture with information obtained through online data |

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| | searches. |
| **Responsible contact** | Gompel, Nicolas |

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| **Title** | Lecture: Animal Communication |
| **Content** | The study of animal communication requires a broader set of perspectives than nearly any other topic in biology. Relevant disciplines include physics, chemistry, neurobiology, cognitive science, evolutionary biology, behavioral ecology, and economics. This lecture on Animal Communication integrates all of these approaches in its treatment of animal signal evolution. The taxonomic scope is kept broad, and all sensory modalities are discussed. Topics begin with the physics and physiology of signal production, propagation, and reception, turn to the behavioural ecology of cooperating communicators, and end with the complications arising when sender and receiver do not have identical interests during communication. |
| **Learning outcomes** | Physical and chemical modes of animal communication<br>Sensory ecology and its neurobiological foundations<br>Behavioural ecological foundations of cooperation and conflict in communication |
| **Responsible contact** | Gahr, Manfred |

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| **Title** | Lecture: Vestibular and Ocular Disorders |
| **Content** | The lecture series will provide students with a foundation of knowledge of various diseases and dysfunctions of the vestibular and ocular motor systems. The course with cover the relevant anatomical structures, diagnostic procedures, patient signs and symptoms, differential diagnoses, and treatment for the most common disorders. Relevant research in the field will also be discussed. |
| **Learning outcomes** | Acquire a perspective of a selection of diseases and disorders of the vestibular and the ocular motor systems<br>Gain an understanding of the anatomical structures involved in disease and dysfunction<br>Learn diagnostic procedures for vestibular and ocular motor disorders<br>Learn differential diagnoses for central and peripheral lesions |
| **Responsible contact** | Zwergal, Andreas |

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| **Title** | Lecture: Comparative Anatomy and Evolution of the Vertebrates |
| **Content** | The lectures provide theoretical background on evolutionary issues of the vertebrate body. This will be presented within the scope of animal evolution in general. In conjunction with paleontological evidence, evolutionary changes of the skeleton will be covered. Furthermore, molecular mechanisms of evolutionary alterations will be discussed. A special focus of the lectures will be on brain evolution. |
| **Learning outcomes** | The lectures will enable students to understand and describe changes of anatomical and physiological characteristics of living and extinct vertebrates in the context of evolution. The students will understand general evolutionary ideas and learn to discuss them with scientists and laypersons in theory as well as by using vertebrate examples. |
| **Responsible contact** | Kunz, Lars |

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| **Title** | Lecture: A Basic Introduction to Conventional MRI and Analysis Techniques for Neuro-Applications |
| **Content** | Starting from basic principles of electromagnetism, elementary spin physics and relaxation mechanisms will be explained. Special emphasis will be placed on an in depth understanding of basic MR experiments, namely the gradient echo and the spin echo, because it lays the foundation for understanding pulse sequences and MR image formation. Building on this knowledge, the most common pulse sequences and image contrasts, used for neuroradiological and neuroscientific applications, will be introduced and illustrated by application examples. In order to prepare participants to be able to interpret MR examinations and discern potential findings from image artifacts, the origin and appearance of common artifacts including means to avoid them will be explained. Finally, the course covers the basics of functional MRI based on the blood oxygenation level dependent (BOLD) effect, as used for preoperative functional brain mapping and neuroscientific applications, including basic image processing and analysis techniques. In this context, the participants should be able to understand the pipeline from image acquisition to parametric maps of brain |

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| | activation as well as their significance. |
| **Learning outcomes** | Upon completion of this course, participants should<br>- be able to explain the principles of MR signal generation and image formation<br>- know the most important image contrasts and how they are generated<br>- know common clinical MR imaging techniques and their applications<br>- know common imaging artifacts and how to avoid them<br>- be able to explain the principles of BOLD-based functional MRI |
| **Responsible contact** | Preibisch, Christine |

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| **Title** | Lecture: Human Brain Imaging and Neuropsychiatric Disorders |
| **Content** | The lecture introduces into the clinical neuroscience of selected neuropsychiatric disorders – ranging from 'classical' psychiatric disorders to neurological diseases with psychiatric symptoms. Emphasis is on neuroimaging of patients and – if possible – a summarizing pathophysiological model. Addressed disorders are Schizophrenia, Autism, Obsessive-Compulsive Disorder, Chronic Pain, Premature Birth, and Multiple Sclerosis. |
| **Learning outcomes** | Brain changes in patients of distinct neuropsychiatric disorders; summarizing pathophysiological models; brain imaging techniques. |
| **Responsible contact** | Riedl, Valentin |

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| **Title** | Lecture: Psychoacoustics and Audiological Applications |
| **Content** | Binaural hearing: binaural cues, masking, directional hearing, movement perception, precedence effect, models;<br>Hearing impairment: Kinds of hearing impairment, frequency selectivity and auditory filters, masking and across-frequency processes, loudness and recruitment, temporal and spectral processing, pitch perception, models of peripheral processing;<br>Speech understanding: cues, models (Articulation |

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| | Index, Speech Intelligibility Index), binaural speech understanding, effect of noise and reverberation on speech understanding;<br>Auditory scene analysis;<br>Music perception: Harmony, consonance, dissonance;<br>Hearing aids: function and algorithms;<br>Cochlear implants: function, algorithms, temporal and spectral resolution, speech understanding;<br>Excercise course: Methods for listening tests and their evaluation; basic statistics for the evaluation of experiments; ethical considerations in clinical research with human participants; speech tests in audiometry; models of the auditory system with hands-on programming in Matlab (monaural, binaural, speech); fitting of hearing aids and cochlear implants; audio demonstrations. |
| **Learning outcomes** | Upon completion of the module the student understands important mechanisms of the auditory system for speech understanding, music perception, directional hearing and listening in noise and is able to apply this knowledge to models of the auditory system and to algorithms for hearing devices. Students further understand methods for conducting and analyzing listening tests and will be able to apply them in a research or audiological context. |
| **Responsible contact** | Seeber, Bernhard |

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| **Title** | Lecture: Computational Neuroscience: A Lecture Series from Models to Applications |
| **Content** | "Computational Neuroscience: A Lecture Series from Models to Applications" is an interdisciplinary lecture series taught by neuroscience experts from TUM and LMU. Students will receive an overview of the various aspects pertaining to computational neuroscience, beginning with the neurobiological foundation and the mathematical tools and extending to applied fields such as auditory prostheses and clinical examinations. Students take part in the lecture and additionally learn the course content during self study with the materials provided by the lecturers (Handouts, further reading advice). The topics are grouped into three areas<br>A. General overview: Anatomical and physiological basis of neuroscience<br>B. Modeling: Neural dynamics and coding<br>C. Towards integration in the nervous system<br>D. Engineering for Neuroscience and Neuroprothetics<br>Basic knowledge of biology and mathematics |

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| | recommended. |
| **Learning outcomes** | In the written examination, an overview of the various aspects of computational neuroscience will be tested. Knowledge-based learning outcomes from the lecture as well as the understanding and ability to solve (practical) problems will be assessed in a 60 min written examination with questions set and corrected by the respective lecturers. After taking part in this course, students are familiar with basic neuroanatomy and the neural processes in different sensory system (visual, auditory, vestibular). Students will learn the fundamental methods for modelling neural behaviour on the cell and the systemic level and how data to fit those models can be obtained from experiments. Additionally, students will learn how such models can be used for engineering neural systems. |
| **Responsible contact** | Thurley, Kay |

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| **Title** | Seminar: Neurobiology of Cognition |
| **Learning outcomes** | Students are trained to read and understand original scientific literature. They learn how to visualize and present complex experimental approaches to a mixed audience, consisting of undergraduates and PhD students. Ideally, they should learn to separate the important from the less important information. They should also learn to be critical of the data in a scientific publication. |
| **Responsible contact** | Hübener, Mark |

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| **Title** | Seminar: Current Topics in Neurodegeneration - Exploring the next steps in research |
| **Content** | This seminar has 2 parts. First, paper dealing with current topics in neurodegenerative research will be discussed as part of a literature seminar (each student will be assigned 1 paper). Subsequently, each student |

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| | is supposed to write a short (!) research proposal exploring their own research ideas based on a paper presented. An introduction as well as supervision for writing research proposals will be provided. |
| **Learning outcomes** | Practice for writing applications for fellowships and developing own ideas for Master/PhD projects as well scientific writing in general. |
| **Responsible contact** | Leonhardt, Heinrich |

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| **Title** | Seminar: Advanced Seminar in Computational Neuroscience |
| **Content** | Current Research Topics in Computational Neuroscience: Recent journal papers and research reports of local laboratories. |
| **Learning outcomes** | Students will get an overview over the current state of research and presently applied methods. |
| **Responsible contact** | Leibold, Christian |

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| **Title** | Excercise: Practical course and Seminar: Computational analysis of RNA-Seq data |
| **Content** | Whole transcriptome analysis by RNA-seq is on the verge of becoming a standard analysis in many molecular biology laboratories. As it is the case for many next generation sequencing (NGS) based methods, the analysis of the data is often more complex than the generation of the data and biologists often (wrongly) believe that the analysis falls in the domain of bioinformaticians. This course aims to set this record straight by enabling students to analyse RNA-seq data by executing and most importantly understanding the following steps: 1. Basic handling skills of NGS data accessing a unix server via the shell commandline. 2. Normalisation and outlier removal of RNA-seq data. 3. Differential expression analysis. 4. Gene-set enrichment analysis. 5. Gene expression network analysis. |
| **Learning outcomes** | This course enables students to analyse RNA-seq data starting from raw sequence files ending with expression network analysis. |

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| **Responsible contact** | Enard, Wolfgang |

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| **Title** | Excercise: Methods in Functional Imaging |
| **Content** | The goal of this practical course is to give students the tools, knowledge and hands-on experience needed to plan, conduct and analyse a task-based fMRI or PET experiment. In the first week of the course, there will be theoretical lectures on data acquisition and analysis as well as guided tutorials on how to analyse fMRI and structural MRI data with SPM12 and Melodic in FSL. The tutorials are self-paced. In the second week, you will be asked to analyse a data set on your own and write a short report to be handed in at the end of the course. |
| **Learning outcomes** | Basic methodology and planning of FMRI experiments. Aquisitation, analysis and discussion of FMRI data. |
| **Responsible contact** | Flanagin, Virginia |

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| **Title** | Excercise: Mass spectrometry and proteomics for functional analysis of disease |
| **Content** | The course will cover basics in mass spectrometry including discovery and targeted workflows for protein identification and quantification (SILAC, ICPL, label-free, selected reaction monitoring). We offer hands-on training on a complete workflow from sample preparation, liquid-chromatography mass spectrometry (on OrbitrapXL), protein identification (Mascot search engine) and relative quantification (label-free quantification, MaxQuant and Progenesis) and the results obtained during the course will be compiled in a joint scientific poster. |
| **Learning outcomes** | Course aim is the understanding the concept of quantitative proteomics as a tool for functional analyses of (patho-)physiology and to gain competence on decision for the best proteomic strategies for specific research questions. |
| **Responsible contact** | Hauck, Stefanie |

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| **Title** | Excercise: Methods in Clinical Neuroscience |
| **Content** | Neuroscience has transformed our understanding of the healthy brain and promises treatments for its disorders. Clinical neuroscience translates these findings into clinical practice. This course is both intended as hands-on approach of the lecture "Clinical Neuroscience" and aimed at students interested in and/or having to deal with the mindset of clinical neuroscientists. |
| **Learning outcomes** | The practical course includes the following topics: Structural and functional brain imaging (MRI, EEG, fNRIS), modulation of the human brain (tDCS, TMS, Neurofeedback), research involving patients (including ethical considerations and practical approach), case reports, clinical trials and epidemiology. Participation in the lecture "Clinical Neuroscience" is complimentary, but not required. The participants will be required to give an oral presentation on a recent peer reviewed publication selected by our lecturers. |
| **Responsible contact** | Kirsch, Valerie |

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| **Title** | Excercise: Comparative Anatomy and Evolution of the Vertebrates |
| **Content** | Based on the theoretical knowledge and paleontological evidence taught in the accompanying lecture, the students will dissect and analyse representative species of major vertebrate groups (e.g. chondrichthyes, osteichthyes, amphibians, lepidosaurs, birds, mammals). Additional anatomical and physiological knowledge will be provided in the daily introduction. The dissections will be performed with the focus on one organ system on each day (e.g. digestive tract, heart and vascular system, swim bladder, lungs & gills, urogenital system, sensory organs and brain, skull, skeleton, musculature). An important component of the course is the presentation of the dissected animals by the students and its discussion within the context of evident evolutionary changes. The course includes short talks given by students on important issues related to the respective organ systems. In addition, there will be a museum visit to focus on the fossil evidence of evolution. |
| **Learning outcomes** | The course will enable students to understand and describe evolutionary changes of organ systems in |

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| | different vertebrates based on their dissection of these animals. The students will be exposed to a variety of vertebrates, including established model systems used in biomedical and basic research (e.g. teleost fish, frogs and rodents), widening the systemic viewpoint for their future experimental work. The students' presentations of theoretical knowledge and of the results of the dissections will enable them to intellectually embrace their work. |
| **Responsible contact** | Kunz, Lars |

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| **Title** | Excercise: Practical Course Auditory Electrophysiology |
| **Content** | This course offers practical training in performing in vivo extracellular recordings in the mammalian auditory brainstem and midbrain. |
| **Learning outcomes** | Students will be able to observe various firing properties of individual neurons in response to acoustic stimulation and to decipher the functional circuits underlying these neuronal properties. |
| **Responsible contact** | Pecka, Michael |

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| **Title** | Excercise: Measuring Molecules with Electrochemical Techniques |
| **Content** | In this practical course students will get familiarized with electrochemical methods used to monitor neurotransmitters and neuromodulators. |
| **Learning outcomes** | Students will have the opportunity to build and test different electrochemical sensors and in vitro. General notions on analysis of sensor performance will be applied on the fabricated electrodes. |
| **Responsible contact** | Santos, Ricardo |

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| **Title** | Lecture and Practical Course: Basic 2-Photon Microscopy Applied to Functional Brain Activity |

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| **Content** | Two-photon fluorescence microscopy allows three-dimensional imaging of biological specimens in living tissue. In the first part of course we will describe the architecture and the advantage of using two-photon microscopy technology in the imaging of brain activity. |
| **Learning outcomes** | The second part will focus on practical demonstration of neuronal activity recording in ex vivo brain specimen. |
| **Responsible contact** | Sgobio, Carmelo |

## Summer Term

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| **Title** | Excercise: Introduction to Patch-Clamp Recordings |
| **Content** | The course provides 1) an introduction into ion channels and receptors in the central nervous system, 2) basics in patch-clamping and 3) analysis of electrophysiological data. The course consists of three lectures, a two-week lab practical (6 hours/day) and an oral presentation by each student at the last day of the course. |
| **Learning outcomes** | Students will learn to prepare acute brain slices of the rodent brainstem and use voltage-clamp and current-clamp recordings to investigate ion channels and receptors in the mammalian brain. Namely, they will characterize intrinsic and synaptic properties of neurons. In addition, they will be introduced to basic electrophysiological data analysis tools. |
| **Responsible contact** | Kopp-Scheinpflug, Cornelia |

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| **Title** | Excercise: Introduction to Event related Potential Recordings |
| **Content** | The course provides 1) an introduction into non-invasive event-related potentials following auditory stimulation, 2) basics in animal handling and anaesthesia and 3) analysis of electrophysiological |

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| | data. The course consists of two lectures, a two-week lab practical (6 hours/day) and an oral presentation by each student at the last day of the course. |
| **Learning outcomes** | Students will learn how to record Auditory Brainstem Responses (ABRs) following acoustic stimulation in mice. They will plan and conduct their own experiment to mimic real-life acoustic challenges as for example acoustic over exposure as present during a rock concert or temporary conductive hearing loss as present during acute Otis media. In addition, they will perform analysis and statistics of the recorded Auditory Brainstem Responses (ABRs). |
| **Responsible contact** | Kopp-Scheinpflug, Cornelia |

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| **Title** | Lecture: Human genomics II |
| **Content** | This lecture covers advanced aspects of human genomics and their biomedical relevance. Building partially on the topics covered in Human Genomics I, it focuses on using human genomics to map disease genes and to understand and diagnose cancer. |
| **Learning outcomes** | The students know how human genomics is used to study human diseases and cancer. |
| **Responsible contact** | Enard, Wolfgang |

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| **Title** | Lecture: Basic Introduction to Advanced MRI and Analysis Techniques for Neuro-Applications |
| **Content** | This advanced MRI course is devised as interactive lecture with elements of hands on training. In order to provide insight into relevant applications, neuroradiological and neuroscientific imaging examples will be given throughout the course. The lecture covers advanced magnetic resonance imaging (MRI), basic spectroscopy (MRS) as well as sophisticated analysis methods. The primary aim is to give a wide overview on a variety of methods and provide the participants with a basic working knowledge on which physiologically and metabolically relevant information can be obtained by MRI and MRS, and how it can be refined by suitable analysis techniques. The course primarily aims at a conceptual |

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| | understanding of the most important principles of the presented techniques and demonstrates relevant applications in clinical practice as well as research. It is intended to enable the participants to identify suitable applications and also recognize technological limitations. The range of covered techniques comprises quantitative relaxometry, diffusion weighted and tensor imaging, qualitative and quantitative oxygenation sensitive imaging (BOLD), qualitative and quantitative flow and perfusion imaging, qualitative and quantitative susceptibility sensitive techniques as well as metabolic imaging by means of MR spectroscopy. Likewise, the presentation of advanced analysis methods primarily aims at a basic understanding of more sophisticated techniques of structural and functional connectivity analysis, graph methods, functional parcellation, effective and dynamic functional connectivity. In addition, practical application examples will be given, relying on the capabilities of open source software packages for processing and analyzing brain MRI. |
| **Learning outcomes** | Limitations of conventional (f)MRI, indications for quantitative and physiological MRI and MRS techniques, basic working knowledge of advanced methods for mapping of relaxation, susceptibility and diffusion properties as well as flow and perfusion, basic understanding of more sophisticated advanced analysis techniques. |
| **Responsible contact** | Preibisch, Christine |

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| **Title** | Lecture: Translational Neuropsychiatry |
| **Content** | The lecture introduces into translational neuroscience of selected neuropsychiatric disorders – ranging from 'classical' psychiatric disorders to neurological diseases with psychiatric symptoms. It continues the lecture 'Imaging Neuropsychiatry'. Emphasis is on selected pathophysiological models and how evidence for these models, which comes from animal research, is translated into human clinical neuroscience. Addressed disorders are Schizophrenia, Chronic Pain, Premature Birth, and Multiple Sclerosis. |
| **Learning outcomes** | Pathophysiological models for selected neuropsychiatric disorders; translational approach. |
| **Responsible contact** | Riedl, Valentin |

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| **Title** | Lecture: Signal Processing for Audio Technology |
| **Content** | The module "Signal processing for audio technology" teaches fundamental approaches for the digital processing of audio signals in a 2-hour lecture. Techniques required for processing audio signals in computational auditory models, in hearing aids, in cochlear implants, for virtual acoustics and for processing music signals are taught. |
| **Learning outcomes** | In the 4-hour practical part students will solve programming assignments which cover basic methods for audio signal processing in a practical context. The topics are selected from the lecture, for example implementations of music effects, dynamic compressors, or binaural synthesis. Besides methods for audio processing the module will teach programming skills in Matlab." |
| **Responsible contact** | Seeber, Bernhard |

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| **Title** | Lecture: Introduction to Scientific Programming in Python |
| **Content** | Introduction to the Python programming language, with a focus on practical tools and techniques for scientific data analysis. Previous programming experience in a language such as Matlab or R is an asset, but not required. Introduces various key Python libraries, and provides example problems. |
| **Learning outcomes** | Students will be encouraged to bring their own specific data analysis problems to class, for immediate applicability to their work, culminating in a course project. Basic command line operations and code version control with Git will also be covered. Homework exercises will be assigned. |
| **Responsible contact** | Spacek, Martin |

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| **Title** | Lecture: Computational Neuroscience: A Lecture Series from Models to Applications |
| **Content** | A. General overview: Anatomical and physiological basis of neuroscience (2lectures)<br>B. Modeling: Neural dynamics and coding (4 lectures)<br>C. Towards integration in the nervous system (4 lectures)<br>D. Engineering for Neuroscience and Neuroprothetics (3-4 lectures)<br>Students take part in the lecture and additionally learn the course content during self study<br>with the materials provided by the lecturers (Handouts, further reading advice). The lecture<br>will be presented by several experts in their respective fields. Students will receive an<br>overview of the various aspects pertaining to computational neuroscience, beginning with<br>the neurobiological foundation and the mathematical tools and extending to applied fields<br>such as auditory prostheses and clinical examinations.<br>In the written examination, an overview of the various aspects of computational<br>neuroscience will be tested. Knowledge-based learning outcomes from the lecture as well<br>as the understanding and ability to solve (practical) problems will be assessed in a 60 min<br>written examination with questions set and corrected by the respective lecturers.<br>Basic knowledge of biology and mathematics recommended. |
| **Learning outcomes** | This interdisciplinary lecture series taught by neurosience experts from TUM and LMU provides an introduction to computational neuroscience. After taking part in this course<br>students are familiar with basic neuroanatomy and the neural processes in different sensory system (visual, auditory, vestibular). Students will learn the fundamental methods<br>for modelling neural behaviour on the cell and the systemic level and how data to fit those models can be obtained from experiments. Additionally, students will learn how such<br>models can be used for engineering neural systems. |
| **Responsible contact** | Thurley, Kay |

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| **Title** | Lecture: Research Data Management in Neuroscience |

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| **Content** | Introduction to research data management concepts and practices. Data organization and annotation; workflows and provenance; reproducibility and sharing; FAIR principles; data management plans; IP rights, licensing, data publication; repositories and databases. |
| **Learning outcomes** | Data organization and annotation; workflows and provenance; reproducibility and sharing; FAIR principles; data management plans; IP rights, licensing, data publication; repositories and databases. |
| **Responsible contact** | Wachtler, Thomas |

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| **Title** | Seminar: Structural and Functional Connectomics in Neuroimaging |
| **Content** | Theoretical concepts and hands-on sessions in Neuroimaging. |
| **Learning outcomes** | This seminar covers the assessment of the structural and functional human connectome with magnetic resonance imaging (similar to the Human Connectome Project). Large part of the seminar will be devoted to hands-on practice. Theoretical concepts and clinical applications. Handson sessions on data preprocessing, connectomics and statistical analysis. |
| **Responsible contact** | Düring, Marco |

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| **Title** | Seminar: Neurobiology of Sleep |
| **Content** | The seminar provides a detailed introduction into the neurobiology and neuroethology of sleep. |
| **Learning outcomes** | We will take a close look into the evolution of sleep behavior across the animal kingdom and tackle the central question: Why do animals (including humans!) sleep?<br>Clinical aspects of sleep impairments will complete our approach to one of our most important behaviors: SLEEP. |
| **Responsible contact** | Fenzl, Thomas |

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| **Title** | Seminar: Neurobiology |
| **Content** | In this seminar original papers of current topics in from different fields of Neuroscience will be presented by the students and discussed. The list of papers will be supplied at the introductory meeting. |
| **Learning outcomes** | Searching for literature, preparing talk outline including time management, discussion of literature. |
| **Responsible contact** | Straka, Hans |

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| **Title** | Seminar: Advanced Topics in Brain Stimulation |
| **Content** | Seminar on advanced methodological topics in brain stimulation methods, chiefly TMS and tCS. Prerequisite is familiarity with the methods through previous courses such as my Winter GSN course. |
| **Learning outcomes** | Participants must read and actively engage in scientific discussion, and write a written report on any one of the issues discussed at the end of the year. |
| **Responsible contact** | Taylor, Paul |

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| **Title** | Excercise: Patch-clamp recordings, optophysiology, in vivo structural plasticity and data analysis |
| **Content** | This training course will cover the preparation of acute cortical or hippocampal brain slices from mice, training in patch-clamp recordings for electrophysiological analysis of neurons, 2-photon imaging and reconstruction of labeled neurons, optophysiological stimulation of synapses using optogenetics or glutamate uncaging, cranial window preparation, in vivo 2-photon imaging of structural plasticity, data analysis and basic programming, as well as related literature review. |
| **Learning outcomes** | Students will learn how to plan, perform, analyse and discuss experiments in patch-clamp recordings. |
| **Responsible contact** | Scheuss, Volker |

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| **Title** | Excercise: Behavioural Profiling of Mice |
| **Content** | Animal models are a vital cornerstone for the understanding of neuroscience-related disorders and the foundation for translational research from the bench to the clinic. The choice of the best suited animal model together with the best behavioural readout is essential for the success of the research project. |
| **Learning outcomes** | The aim of the course is to motivate young students at the beginning of their carrier to think about the implications of their choice of research models and behavioural tests. The students will plan, perform and analyze several behavioural tests in mice. |
| **Responsible contact** | Schmidt, Matthias |

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| **Title** | Excercise: Experimental stroke research – Introduction to laboratory animal science |
| **Content** | This course will provide a brief inside into experimental laboratory animal science with special focus on experimental models in stroke research. It covers basic knowledge about laboratory animal science (legal and ethical principles, 3Rs, database searches, experimental design, statistical analysis), as well as principles in biology, breeding and husbandry requirements. |
| **Learning outcomes** | Theoretical and practical introduction and demonstration of state-of-the-art experimental models in stroke research. |
| **Responsible contact** | Schneider, Manuela |

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| **Title** | Excercise: Signal Processing for Audio Technology |
| **Content** | The module "Signal processing for audio technology" teaches fundamental approaches for the digital processing of audio signals in a 2-hour lecture. Techniques required for processing audio signals in computational auditory models, in hearing aids, in |

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| | cochlear implants, for virtual acoustics and for processing music signals are taught. |
| **Learning outcomes** | In the 4-hour practical part students will solve programming assignments which cover basic methods for audio signal processing in a practical context. The topics are selected from the lecture, for example implementations of music effects, dynamic compressors, or binaural synthesis. Besides methods for audio processing the module will teach programming skills in Matlab. |
| **Responsible contact** | Seeber, Bernd |