Compulsory Modules

Neuromorphology				UNIVERSITÄT BONN
Module Number PM 1	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Benjamin Odermatt			
Teaching Unit offering the module	Anatomical Institute			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		compulsory	1. sem
Learning Outcomes	Students will learn the basic structures of nerve cells and how these may be arranged into functional units. Students need to learn the developmental relationship of germ layers and the nervous system in mammals. By the end of the module they should be able to describe, examine, identify, label and list cellular elements and subsystems of the CNS. They should familiarize themselves with basic molecular-morphological techniques such as immunostaining, transgenic tagging, (quantitative) microscopy and morphometry. Students will study how to associate basic descriptive knowledge to clarify morphological classifications of the nervous system and how to use this knowledge to decode and distinguish the morphological underpinning of specific functions; they should learn to generalize morphological data and its interpretation to examine the structure and development of nerve cells and nervous systems (i.e. the murine cerebellum, the zebrafish spinal cord, and murine nerve cells in primary culture. They will learn to present (i.e. poster session) interpret, demonstrate and debate their findings.			
Contents	This module encompasses a combined series of lectures, seminars and lab work which will provide an advanced view of selected and central topics of functional neuroanatomy, ranging from the cellular to the system level. Examples will be mostly drawn from murine and human model systems. The following issues shall be dealt with: A. Cell biology of neural cells: structure and function of synapses; axonal transport; morphological basis of functional compartmentation of signal transduction and processing; structure and function of astroglial cells; myelin forming cells; neuron-glia interactions; B. Systems-oriented neuroanatomy: evolutionary basis of functional anatomy of the mammalian nervous system; basic aspects of nervous system development; discussion on selected functional systems based on their involvement in paradigmatic human neuropsychiatric diseases (e.g. Parkinson's disease; cerebrellar ataxias) There is a strong focus on hands-on practical methods including tissue preparation, immunostaining, transgenic tagging, microscopy and morphometry. The seminar is aimed at providing a forum for the acquisition of advanced conceptual and methodological skills based on the discussion of current scientific literature pertinent to the basic theme of the module.			
Prerequisites for participation	none			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	morphology of the mammalian nervous system	20	1.3	60
	Practical course	morphological approaches to study the nervous system		2.6	105

	Seminar	current topics of neuromorphology 20 participants		0.7	60
Examinations	Type of examination(s)			Graded/non-graded	
	Written examination			graded	
Study elements required as prerequisite for admission to the module examination	attendance of seminars and practical course oral presentation in seminar with moderation of subsequent discussions preparation and presentation of a poster documenting experimental findings and their interpretation			graded/non-graded Non-graded	
Additional information	Recommended Reading: Swanson, L.W. Brain Architecture, Understanding the Basic Plan, Oxford University Press 2012 (2nd edition) Brodal, P. The Central nervous system. Structure and function. Oxford University Press 2010 (4th edition). Notably Chapters 1-6, 9, 12-15, 20-22, 24 Original literature for the seminars will be selected from the actual literature.				

Neurophysiology				UNIVERSITÄT BONN
Module Number PM 2	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Christian Henneberger			
Teaching Unit offering the module	Institute of Cellular Neurosciences			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	compulsory	1. sem

Learning Outcomes	Students will learn about CNS function on the levels of ion channels, cells and cellular networks. By the end of the module they will have gained the ability of neurophysiological data acquisition, analysis, interpretation and presentation. The accompanying seminar will improve the understanding of information provided through lectures. This knowledge will be a prerequisite to successfully accomplish subsequent neurophysiological core course modules. Students should apply basic knowledge of neurophysiology in behavioural and electrophysiological experiments and conduct basic microscopy. Students should analyse data and summarize them in written protocols.
Contents	Participants receive basic and advanced knowledge of neurophysiology and information about relevant methods (e.g. evoked potentials, extra- / intracellular, patch clamp recordings). Properties of ion channels as well as cellular and network properties of selected model systems (leech, goldfish, hippocampus) will be discussed.
Prerequisites for participation	None

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Neurophysiology	20	2.0	60
	Practical Course	Neurophysiological Methods		2.0	60
	Seminar	Functions of neurons and synapses		2.0	105

Examinations	Type of examination(s)	Graded/non-graded
	Oral examination **A factually correct protocol accepted by the supervisor is prerequisite for admission to the examination.**	graded

Study elements required as prerequisite for admission to the module examination	attendance of seminars and practical course oral presentation in seminar with moderation of subsequent discussions	graded/non-graded Non-graded

Additional information	Recommended Reading: - Kandel ER, Schwartz JH, Jessell TM (2004) Principles of neural science. 4th ed.) McGraw-Hill - Galizia CG, Lledo P-M (2013) Neurosciences From Molecule to Behavior. Springer - Hill R.W., Wyse G.A., Anderson M. (2012) Animal Physiology (3rd ed). Sinauer Associates

Mitochondrial proteostasis				UNIVERSITÄT BONN
Module Number PM 3	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Winter Term

Person in charge of the module	Prof. Dr. Thomas Becker
Teaching Unit offering the module	Institute of Biochemistry and Molecular Biology

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	compulsory	1. sem

Learning Outcomes	The aim of the module is to gain advanced knowledge about the structure of neurons and the molecular processes involved in neuronal communication. By the end of the module students should understand molecular and cell biology of axonal transport, synaptic transmission and its modulation and become familiar with the biochemistry of neurotransmitter synthesis, inactivation and degradation. The essential functions of non-neuronal cells will be covered. Students will be introduced in the pathobiochemistry of selected diseases. They should apply their knowledge while conducting basic biochemical experiments and analyse data obtained from the conducted experiments.
Contents	1. Mechanisms of axonal transport, neuronal cytoskeleton, neurite outgrowth, extracellular matrix, neurotrophic factors 2. Mechanisms of synaptic transmission, vesicles, Snare's, structure, synthesis and inactivation of neurotransmitters, neurotransmitterreceptors, signal transduction pathways Pre and post synaptic signal modification 3. specific features of non-neuronal cells astrocytes, oligodendrocytes, microglia, Composition, synthesis and function of myelin, biochemistry and function of astrocytes and microglia Pathobiochemistry of Alzheimer disease, prion diseases, leukodystrophies, polyglutamin diseases and multiple sclerosis
Prerequisites for participation	None

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Molecular Neurobiology	20	1.3	60
	Practical Course	Molecular Neurobiology		2.6	105
	Seminar	Molecular Neurobiology		0.7	60

Examinations	Type of examination(s)	Graded/non-graded
	Oral examination	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practical courses, oral presentation in seminar	graded/non-graded Non-graded

Additional information	Recommended Reading: 1. Kandel, Schwartz, Jessel, Principles of Neural Sciences, Mc Graw Hill Purves, Neuroscience, Sinauer Associates

Statistics, Scientific writing, Research ethics **(module consists of three seminars)**				UNIVERSITÄT BONN
Module Number PM 4	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Winter-/Summer Term
Person in charge of the module	PD Dr. Ronald Jabs Prof. Dr. Ina Vorberg Prof. Dr. Dirk Lanzerath			
Teaching Unit offering the module	Institute of Cellular Neurosciences DZNE German Reference Centre for Ethics in the Life Sciences (DRZE) & Institute of Science and Ethics (IWE)			
Applicability of the module	Study Program		Modus	Study Semester
	MSc Neurosciences		compulsory	2., 3. Sem.
Learning Outcomes	**Statistics**: Students will gain an understanding of hypothesis testing and correct interpretation of different types of test statistics. In the seminar students will acquire to reflect and to analyze the learned content in direct communication with the instructors. They improve their practical skills in statistical calculations and adequate planning of experiments. They will be introduced to the software package "R". Students will work with their own data sets. This will include data transfer, plotting and implementation of standard statistical tests. **Scientific writing**: Improvement of the competence for scientific writing. This includes the writing of protocols, master thesis, Ph.D. thesis, and manuscripts. First, students will learn about the structure of a manuscript and the function and importance of each section (abstract, introduction, methods, results, discussion, references). They will develop the ability for a clear and elegant writing style. Students will familiarize with the ethical implications of scientific writing. **Research ethics**: Knowledge of main approaches and methods in current bioethics and research ethics. Students will learn to understand central ethical questions raised by research, in particular neuroscientific research and to analyze ethical issues in the context of the life sciences and to apply standard arguments developed by research ethics. They will gain the ability to evaluate ethical arguments related to neuroscientific research.			
Contents	**Statistics**: Basic test theory; χ^2-tests for contingency tables; t-Test; non-parametric tests; analysis of variance (ANOVA); multiple testing; power calculations; calculation rules for probabilities and neurobiological applications; guidelines for choice of analysis strategy; software implementations; effect size based hypothesis testing **Scientific writing**: ▪ Introduction into general guidelines and rules for scientific writing. ▪ Introduction into the elements of style. ▪ Analysis and discussion of scientific texts. ▪ How to improve and correct a text. ▪ Practices in writing. Students will write their own texts and correct and make suggestions for improvements of the texts of others. **Research ethics:** ▪ Main approaches and methods in current research ethics ▪ Ethical standards of good scientific practice ▪ Ethical issues related to research with humans ▪ Ethical issues related to animals ▪ Ethical issues related to research with biological material			
Prerequisites for participation	None			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Statistics	**Statistics**	20		
	Lecture:	Statistics		2.0	75
	Practical course	Statistical Analysis		1.2	40
	Scientific writing				
	Lecture	Scientific writing		0.6	25
	Practical course	Scientific writing		0.6	25
	Research ethics				
	Lecture	Research Ethics		0.8	30
	Seminar	Research Ethics		0.8	30
,Examinations	Type of examination(s)			Graded/non-graded	
	Top pass this module you have to pass three submodule examinations!! **Statistics**: Final written examination **Scientific writing:** Writing of an abstract and introduction for a scientific paper **Research ethics**: Final written examination			Graded Graded Graded	
Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practical courses			graded/non-graded	
Additional information	This module consists of three submodules (seminars)! Recommended Reading: **Statistics** :Primer of Biostatistics S.A. Glantz, McGrawHill Medical **Scientific writing**: - Scientific writing booklet, Marc. E. Tischler - The Chicago Manual of Style & The Elements of Style, William Strunk Jr. - Writing Scientific Research Articles, Margaret Cargill & Patrick O'Connor				

Elective Modules

Cognitive Neuroscience				UNIVERSITÄT BONN
Module Number WPM 6	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	Prof. Dr. Rainer Surges			
Teaching Unit offering the module	Department of Epileptology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	The module provides theoretical and practical understanding of the most popular methods and compiling of the most important findings in cognitive neuroscience including increased awareness for the methodological fundaments and limits of brain science and its impact on traditional philosophical concepts.			
Contents	1. Methodology and Theory of Cognitive Neuroscience • Psychology: what makes it a science? • Experimental strategies: psychophysiology, neuropsychology • Philosophical implications of cognitive neurosciences 2. Cognitive Neuroscience: main findings on brain-function relationships 3. Clinical Neurophysiology and Imaging • Electroencephalography (EEG) as a neurodiagnostic tool • Advanced methods of EEG analysis: coherence, fast Fourier, non-linear and other analysis • Structural and functional brain imaging as neurodiagnostic tools 4. Experimental Psychophysiology • Electrophysiology: event-related potentials, non-invasive and invasive • Magnetic resonance tomography: functional neuroimaging (fMRI) 5. Clinical Neuropsychology • Neuropsychological assessment • Cortical electrostimulation • WADA test 6. Experimental Neuropsychology • Animal models of behavioural deficits in epilepsy			
Prerequisites for participation	None			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	-Lecture -Practical Course -Seminar	-Cognitive Neurosciences -Clinical Psycho-physiology, Event-related potentials / EEG, Functional Imaging /fMRI, Clinical and Experimental, Neuropsychology -Methodology	12	1.0 4.0 1.0	30 165 30

Examinations	Type of examination(s)	Graded/non-graded
	Oral presentation in form of a talk (with written handout).	graded
Study elements required as prerequisite for admission to the module examination	attendance of seminars and practicals writing reports, essays	graded/non-graded Non-graded
Additional information	Recent literature and appropriate textbooks will be recommended.	

Developmental Neurobiology, Stem Cells and Disease				UNIVERSITÄT BONN
Module Number WPM 7	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	Prof. Dr. Oliver Brüstle			
Teaching Unit offering the module	Institute of Reconstructive Neurobiology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	During this practical course students gain insight into the molecular mechanisms underlying the development of the central nervous system in mouse and human. They learn about tools used in mouse genetics and cell programming strategies applied in human stem cell biology. In particular, they acquire knowledge on the generation of iPS cells and their genetic modification via genome editing. After successful participation, attendees should know when to apply these tools for experimentally addressing questions relating to mouse developmental biology, human stem cell biology and genome editing. (Bloom taxonomy: application). Key skills qualifications: Attendees perform immunohistochemistry and RNA in situ hybridization on mouse brain sections and analyze the specimens using advanced microscopy techniques. In addition, students get insight into transcription factor based fate programming, learn to establish 3D cultures and get to know the principles of image-based analyses of cellular phenotypes. A particular focus will be on the development of a project plan to address research questions in the area of neurodevelopment and/or stem cell biology. In this context the possibilities but also limitations of the applied techniques will be discussed with tutors and lectures.			
Contents lecture	• From neurulation to early patterning of the nervous system • Fate instruction and regional determination • Stem cells in the adult brain • Molecular and cellular aspects of cortical development • Developmental neurotoxicity • Glia cells and myelin • Circuit formation in the developing central nervous system • Cell fate specification for retinal repair • Self-organization and 3D cultures • Principles of neural cell replacement • In vitro models of neural development and neurodegeneration • Neurodevelopment, stem cells and psychiatric disease			
Contents practical course	• Introduction into neuroanatomy • Strategies to generate mouse models for the investigation of neurodevelopmental processes • Molecular mechanisms underlying neural fate determination • Forced expression of transcription factors and use of small molecules for forward programming approaches • Direct conversion of somatic cells into neural stem cells • Generation of 3D cultures • Genetically engineered reporter gene systems for image-based phenotypic analysis • Principles of primer design, immunochemistry and network analysis of neuronal circuits • Fluorescence microscopy of 2D and 3D cultures			
Prerequisites for participation	None			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	-Lecture	-Developmental neurobiology and neuroregeneration	3	2.0	60
	-Practical Course	-Experimental Neurobiology		2.0	60
	-Seminar	-Current approaches in developmental neurobiology and neuroregeneration		2.0	105
Examinations	Type of examination(s)			Graded/non-graded	
	oral presentation			graded	
Study elements required as prerequisite for admission to the module examination	Attendance of lecture, seminars and practicals			graded/non-graded	
				Non-graded	
Additional information	Recommended Reading: Molecular Biology of the Cell, 7th ed. Bruce Alberts et al.; Garland Publishing. 2022. Principles of Neural Science 6th ed. Eric R. Kandel et al.; McGraw-Hill Education. 2021.				

Neuroinflammation				UNIVERSITÄT BONN
Module Number WPM 9	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	Prof. Dr. Harald Neumann			
Teaching Unit offering the module	Institute of Reconstructive Neurobiology (Dozent: Prof. Dr. Harald Neumann)			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	Basics of microglia; mechanisms of inflammatory chronic neurodegenerative diseases; link between inflammation and brain aging; inflammatory pathophysiology of psychiatric disorders; introduction to sophisticated cellular and molecular techniques (Flow cytometry, immunostainings, confocal microscopy, image analysis, bioassays, RT-PCR, RNAseq and bioinformatics).			
Contents	• Microglia • Inflammation and brain aging • Neuroinflammation • Neuroimmunology • Inflammatory neurodegeneration • Flow cytometry • Bioassays • RNA analysis • Confocal microscopy and image analysis			
Prerequisites for participation	None			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Neuroinflammatory Diseases	10	2.0	60
	Practical Course	training in neuroinflammation		2.0	60
	Seminar	methods in neuroinflammation		2.0	105

Examinations	Type of examination(s)	Graded/non-graded
	Written examination	graded
Study elements required as prerequisite for admission to the module examination	- attendance of lecture series 'Neuroinflammatory Diseases' (whole semester, each Wednesday from 8.00 to 9.30) - oral presentation as seminar with an accompanying written handout of the training	graded/non-graded Non-graded
Additional information	Recommended Reading: Molecular Biology of the Cell, ed. Alberts; Bruce et al. Principles of Neural Science, ed. Kandel et al.; Janeway's Immunobiology, ed. Murphy et al.	

Principles of Neural Information Processing				UNIVERSITÄT BONN
Module Number WPM 11	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	Dr. Thoralf Opitz			
Teaching Unit offering the module	Institute of Experimental Epileptology and Cognition Research			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	The course is focused on technological and conceptual advances in our understanding of how neurons process information. Topics include the mechanisms governing formation and structural and functional dynamics of the individual contact points between neurons, synapses. They also encompass a discussion of signal integration of tens to hundreds of synapses within the dendritic arbor of neurons, and how this is influenced by subdomain-specific ion channel expression. Furthermore, we discuss modes of output generation in neurons, and modulation of signal transmission. These topics are complemented by lectures dealing with the role of non-neuronal cells in signal transduction. Application: The module has a strong focus on advanced electrophysiological, molecular and imaging techniques, both in-vitro and in-vivo.				
Contents	1. Structure, function, and activity-dependent trafficking of ion channels (voltage gated channels; transmitter gated channels) 2. Properties and functional plasticity of synapses. 3. Dendritic integration and the role of active and passive dendritic properties. 4. Subcellular distribution of ion channels 5. Activity-dependent plasticity (intrinsic and synaptic plasticity; neuron-glia interactions, ion channels in neurological diseases)				
Prerequisites for participation	None				
Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Information processing in neural cells	10	2.0	60
	Practical Course	functional characterization of ion channels		2.0	60
	Seminar	Information processing in neural cells		2.0	105
Examinations	Type of examination(s)			Graded/non-graded	
	Oral examination			graded	
Study elements required as prerequisite for admission to the module examination	attendance of seminars and practicals oral presentation in seminar with an accompanying written handout			graded/non-graded Non-graded	
Additional information	Recommended Reading: 1. Kandel, Schwartz, Jessel, Principles of Neural Sciences, McGraw Hill 2. Johnston and Wu, Foundations of Cellular Neurophysiol., MIT, Bredford 3. Hille, Ionic Channels of Excitable Membranes, Sinauer				

Neurogenetics				UNIVERSITÄT BONN
Module Number WPM 12	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	Prof. Dr. Markus Nöthen			
Teaching Unit offering the module	Institute of Human Genetics			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	2. Sem.

Learning Outcomes	The module 'Neurogenetics' provides students insights into the basics of molecular genetics and molecular principles underlying human genetic diseases and pathologies of the brain. They will acquire basic knowledge of the theoretical and practical aspects of classical and novel technologies for disease gene identification and detection of epigenetic modifications. In addition, they will learn about genetic therapeutical approaches to treat or prevent human diseases and methods to generate animal models, which are powerful tools to unravel the etiology of the disorders. By the end of the module students are able to describe genetic processes causing pathological changes in the brain. They have learned to explain and apply methods and approaches used in neurogenetic research and are able to analyse, interpret and present research results. Moreover, through the accompanying seminars, they will have learned to search, comprehend and critically discuss scientific publications related to the topic of the module.
Contents	• Genetics of complex neuropsychiatric diseases • Genetics of neurological diseases • Epigenetics, mitochondrial genetics, somatic mutations • Animal models of epilepsy • Statistical genetics
Prerequisites for participation	None

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Neurogenetics	12	2.0	60
	Practical Course	Methods in Neurogenetics		2.0	60
	Seminar	Neurogenetics		2.0	105

Examinations	Type of examination(s)	Graded/non-graded
	Written examination	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practicals	graded/non-graded
	Oral presentation in seminar with an accompanying written handout Written protocols to all practical experiments	Non-graded

Additional information	Recommended Reading: 1. Kandel, Schwartz, Jessel, Principles of Neural Sciences, McGraw Hill 2. Strachan, Read, Human Molecular Genetics, Garland Science 3. Thomas, Statistical Methods in Genetic Epidemiology, Oxford University Press 4. Pitkänen, Schwartzkroin, Moshe, Models of Seizures and Epilepsy, Academic Press

Neuropharmacology				UNIVERSITÄT BONN
Module Number WPM 13	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	Prof. Dr. Alexander Pfeifer			
Teaching Unit offering the module	Institute of Pharmacology and Toxicology in cooperation with the Federal Institute for Drugs and Medical Devices			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	2. Sem.

Learning Outcomes	Students will gain broad knowledge on research of drug mechanisms, identification of drug targets and the development of novel drugs in the field of neurological disorders. By the end of the module they will be able to analyse, interpret and present their experimental data and to reflect and apply contents of lectures and seminars. Apart from molecular pharmacology, this module will also cover essential aspects of industrial drug research and development as well as drug regulatory affairs. Accordingly, these interdisciplinary topics will be presented by docents from academia, from pharmaceutical companies and from the Federal Institute for Drugs and Medical Devices (Bundesinstituts für Arzneimittel und Medizinprodukte, BfArM).
Contents	*Topic 1*: Pharmacologically relevant signalling pathways *Topic 2*: Drugs for the treatment of pain: local anaesthetics, opioids *Topic 3*: Drugs influencing vigilance: hypnotics, general anaesthetics *Topic 4*: Treatment of psychiatric diseases: antipsychotics, antidepressants *Topic 5*: Drugs of abuse: opioids, cannabinoids *Topic 6*: Neurodegenerative disorders *Methods 1:* Drug mechanisms and signalling in neurons *Methods 2:* Modulation of neurotransmitter release in brain slices *Methods 3:* Standard behavioural tests in drug development - pharmaceutical industry *Methods 4:* Development of innovative drugs – gene and cell therapies *Methods 5:* Regulatory Affairs
Prerequisites for participation	None

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Neuropharmacology	6	2.5	105
	Practical Course	Methods in Neuropharmacology		2.5	80
	Seminar	Neuropharmacology		1.0	40

Examinations	Type of examination(s)	Graded/non-graded
	Oral examination	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practicals	graded/non-graded
	Full participation in the practical course Written protocols to all practical experiments	Non-graded

Additional information	Recommended reading: Rang & Dale's Pharmacology; Elsevier Goodman and Gilman´s: The Pharmacological Basis of Therapeutics; McGraw-Hill

Protein misfolding and aggregation in neurodegenerative diseases				UNIVERSITÄT BONN
Module Number WPM 18	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	Prof. Dr. Ina Vorberg			
Teaching Unit offering the module	German Center for Neurodegenerative Diseases e.V. (DZNE e.V.)			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	2. Sem.

Learning Outcomes	Students will obtain knowledge about neurodegenerative disorders, such as Huntington's disease, Alzheimer's disease and prion diseases. These diseases are associated with the aberrant folding and accumulation of host encoded proteins that lead to neuronal dysfunction and ultimately neuronal loss. The lecture will provide an introduction into the origins of neurodegenerative diseases and the molecular and cellular mechanisms influencing protein aggregation. In the practical course students will apply common research methods and concepts for studying cellular and tissue aspects of protein misfolding and aggregation. The seminar section will cover the methodological background and primary literature of the field.
Contents	• Cell biological methods: Basic cell culture techniques; transfection; immunofluorescence, confocal microscopy; MTT; histology • Biochemical methods: BCA; SDS PAGE, Western Blot, SDD-AGE, filter trap; immune precipitation • Molecular biological methods: DNA/ mRNA isolation, PCR, RFLP, semiquantitiative PCR
Prerequisites for participation	None

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Neurodegenerative Diseases: From cell biology to pathophysiology	6	1.0	30
	Practical Course	Techniques and protocols to molecular studies of neurodegenerative diseases		4.0	165
	Seminar	Current topics of neurodegenerative diseases and experimental approaches		1.0	30

Examinations	Type of examination(s)	Graded/non-graded
	Oral examination	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars. Full participation in practical course and seminars. Oral presentations in seminar.	graded/non-graded Non-graded
Additional information	Recommended Reading: will be announced at registration	

Neuroanatomy				UNIVERSITÄT BONN
Module Number WPM 20	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term

Person in charge of the module	Prof. Dr. Michael Hofmann		
Teaching Unit offering the module	Institute of Zoology		
Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences, MSc OEP Biology	core course	2. Sem.
Learning Outcomes	Students will learn modern experimental neuroanatomical techniques and investigate the histology and connectivity of brains. Vertebrate and invertebrate animal models will be used to demonstrate the general morphology of the brains. Further, students will apply tracer experiments with both, fluorescent and light stable reactions and learn how to analyze neuronal pathways and connections. Histochemical methods will reveal the distribution of neurotransmitter related enzymes.		
Contents	We will investigate mainly fish brains, but also some invertebrate model systems to get on overview of the major differences in neuronal organization between them. Sensory and motor pathways will be compared and pathways will be traced from primary sensory centres through higher integrative centres to motor command areas.		
Prerequisites for participation	None		

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Basics in Neuroanatomy	4	2.0	60
	Practical Course	Methods in Neuroanatomy		4.0	180
	Seminar	Neuroanatomy		2.0	60

Examinations	Type of examination(s)	Graded/non-graded
	Oral Examination	graded

Study elements required as prerequisite for admission to the module examination	Participation in all parts of the module, presentation of an oral contribution during the seminar	graded/non-graded Non-graded
Additional information		

Assembly of Neural Circuits				UNIVERSITÄT BONN
Module Number WPM 22	Workload 225	Extent 7.5 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Chair: Prof. Dr. Frank Bradke Co-Chairs: Prof. Dr. Gaia Tavosanis, Prof. Dr. Walter Witke, Prof. Dr. Michael Pankratz			
Teaching Unit offering the module	German Centre for Neurodegenerative Diseases e.V. (DZNE), LIMES, Institute of Genetics, PD Dr. Gaia Tavosanis (DZNE), Prof. Dr. Michael Pankratz (LIMES), Prof. Dr. Walter Witke (Institute of Genetics)			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	The students will learn state-of-the art cell biological, genetic and molecular techniques to study circuit formation in vertebrate and invertebrates.			
Contents	• Neuronal cytoskeleton • structural and circuit plasticity • Immunocytochemistry • Time lapse microscopy • Monitoring neuronal activity • Thermo- and Optogenetics			
Prerequisites for participation	None			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Cell Biology of neurons Neuronal Polarity Axon regeneration Dendrite differentiation Structural plasticity Neurophysiology Brain Development	4	1.0	35
	Practical Course	Culturing neurons Immunocytochemistry Videomicroscopy Whole Tissue Imaging Optogenetics Functional imaging Monitoring Neural Activity EM-Reconstruction (?) Thermogenetics		2.5	118
	Seminar	Current Topics in cellular neurobiology		1.5	58

Examinations	Type of examination(s)	Graded/non-graded
	Oral Exam	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practicals	non-graded
	Presentation of relevant research topics/literature	Non-graded
Additional information		

Neuroethology: multiphoton imaging of activity and connectomic mapping of synaptic connectivity				UNIVERSITÄT BONN
Module Number WPM 23	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Winter Term

Person in charge of the module	Prof. Dr. Jason Kerr, Dr. Kevin Briggman		
Teaching Unit offering the module	Dept. of Behavior and Brain Organization, caesar. Dept. of Computational Neuroethology, caesar.		
Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	2. Sem.
Learning Outcomes	Students will learn principles of optical and electron microscopy for imaging the brain at cellular resolution to understand the neuronal basis of behavior. The module will cover the quantification of behaviour in freely moving animals. Students will learn multi-photon (two- and three-photon microscopy) based imaging of neuronal populations in the brains of behaving rodents and fish as well as the use of serial electron microscopy to reconstruct synaptic connectivity. In addition, the module will introduce methods and tools for analysing large-scale imaging data.		
Contents	• quantifying goal-directed behavior in freely moving rodents and fish • constructing, aligning and calibrating a 2-photon *in vivo* microscope • whole-brain imaging in larval zebrafish using 2-photon light sheet imaging • serial sectioning and imaging of brain volumes using scanning electron microscopy • machine-learning assisted analysis of imaging data		
Prerequisites for participation			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Quantification of behavior Optics and laser theory Biological signals from multiphoton imaging Electron microscopy theory EM reconstruction	4	2.0	60
	Practical Course	Behavioral videomicroscopy Build a 2-photon microscope Monitor neural activity Analysis of imaging data Tissue preparation for EM Serial electron microscopy		3.5	150
	Seminar	Students present results from practical course		0.5	15

Examinations	Type of examination(s)	Graded/non-graded
	Oral presentation	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practicals	graded/non-graded
	Oral presentation and protocol	Non-graded
Additional information		

The Synapse: from molecules to information processing				
Module Number WPM 25	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term

Person in charge of the module	Chair: Prof. Dr. D. Dietrich Co-Chairs: Prof. Dr. Susanne Schoch
Teaching Units offering the module	Institute of Neuropathology (Prof Schoch), Dept. of Neurosurgery (Prof Dietrich), Institute of Cellular Neurosciences (Prof Henneberger), Institute of Epileptology and Cognition Research (Dr. Schwarz, Prof. Rose), Institute of Reconstructive Neurobiology (Prof Blaess)

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	2. Sem.

Learning Outcomes	Students will learn about all aspects of the synapse, the key structure of communication and information processing in the brain. The lectures will cover cell biological, biophysical, structural and physiological properties of the synapse and introduce the methods that are being used to study these. The lectures will also address the emerging role of synapses in neurological disorders, termed “synaptopathies” and and the role of astrocytes in controlling neuronal activity by modulating synaptic function. In the practical course students will apply and get to know these methods starting with classical structural, biochemical and molecular approaches over physiological measurements and imaging of synaptic function to exploring the role of synapses for network activity in vivo experiments. The seminars will cover the methodological background and primary literature in the field and help students to effectively read scientific literature.
Contents	• Synaptic Ultrastructure, molecular composition, post-translational modific. • Mechanisms of vesicle release, recycling and filling • Forms of Synaptic Plasticity, scaling and information storage • Diversity of synapses, Synaptic Dysfunction, Glial cells and synapses • Biochemical methods: Synaptosome preparation, SDS PAGE, Western • Time-lapse, confocal, STORM, FLIM and 3D electron microscopy • Optogenetics, genetically encoded sensors of synaptic function • Connectivity in neuronal networks (Connectomics) • Connectivity in neuronal networks (Connectomics)
Prerequisites for participation	None

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	The Synapse: From structure to Function Methods in Synaptic Neuroscience	4	1.5	60
	Seminar	Current literature, ongoing projects Paper presentation		0.5	25
	Practical Course	Experimental approaches to study synapse function		4	140

Examinations	Type of examination(s)	Graded/non-graded
	Oral examination	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars. Successful participation in practical courses, lectures and paper presentation.	Non-graded Non-graded
Additional information	Will be announced at registration.	

Social Neuroscience				
Module Number WPM 28	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	PD Dr. Johannes Schultz			
Teaching Unit offering the module	Institute of Experimental Epileptology and Cognition Research			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	What are the neural mechanisms underlying social interactions? In this module, students will learn about neural mechanisms in primates underlying the detection and identification of living agents, the perception and decoding of the social signals these agents send, and the decisions about interacting with these agents. Brief insights into disorders of social interactions found in psychiatric conditions will then be discussed. These topics will be presented in the lectures, developed in the seminars and students will be able to get hands-on experience with designing and performing social perception and decision experiments in the practical course.			
Contents	• Cognitive neuroscience of social perception and cognition • Dysfunctions of social perception and cognition • Research methods in social neuroscience (signal detection theory; metacognition; experimental psychology; classification methods) • Experimental design			
Prerequisites for participation				

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Social neuroscience	12	1	40
	Seminar	Social neuroscience	12	2	80
	Practical Course	Experimental social neuroscience	12	3	105

Examinations	Type of examination(s)	Graded/non-graded
	Written Examination (Paper)	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practical course	graded/non-graded
	Presentation of relevant literature	Non-graded
Additional information		

Animal Navigation: Behavioural, sensory and neurobiological concepts				UNIVERSITÄT BONN
Module Number WPM 30	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Pascal Malkemper Dr. Bettina Schnell			
Teaching Unit offering the module	Max Planck Institute for Neurobiology of Behavior – caesar			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	In this module, we will study why and how animals move in space and what sensory cues they use to do so in an efficient manner. In the lectures, we will discuss the evolution and ecology of movement and the mechanisms for orientation used by different taxa. We will recapitulate the anatomy and function of sensory systems in both vertebrates and invertebrates and how different modalities are integrated to aid navigation. In the practical course, students will learn how to study animal spatial orientation and the sensory systems involved, using behavioral, electrophysiological, and anatomical techniques as well as genetic manipulations. Experiments will include behavioral, anatomical and electrophysiological work in mice and mole-rats, and behavioural and physiological analyses in Drosophila. In the seminar, students will present and discuss relevant primary literature of the field.				
Contents	• Analysing visually guided flight behaviour in Drosophila • Performing ERG recordings in Drosophila • Orientation assays for small rodents • Analysing electrophysiological and behavioural data from mole-rats • Fluorescent lightsheet imaging of optically cleared sensory organs			
Prerequisites for participation				
Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Sensory ecology and neurobiology of spatial behavior in animals	6	1	30
	Seminar	Current topics and approaches in animal spatial orientation research		1	30
	Practical Course	Methods to study spatial orientation and its sensory basis		4	165
Examinations	Type of examination(s)			Graded/non-graded	
	Oral examination			graded	
Study elements required as prerequisite for admission to the module examination	Attendance and participation at lectures, seminar, and practical course. Oral presentation in seminar. Written protocols of all practical experiments.			graded/non-graded Non-graded	
Additional information	Recommended literature: 1) Hansson & Åkesson 2014 – Animal movement across scales, Oxford University Press				

Neuronal circuit dysfunction of CNS diseases				UNIVERSITÄT BONN
Module Number WPM 31	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	Prof. Stefanie Poll, Prof. Martin Fuhrmann			
Teaching Unit offering the module	Institute of Experimental Epileptology and Cognition Research (IEECR), German Center for Neurodegenerative Diseases (DZNE)			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will gain knowledge about complex experimental approaches to investigate neuronal circuits and their impairments in mouse models of CNS diseases. They will learn about the application of state-of-the-art neuroscience tools combined with cutting-edge *in vivo* microscopy techniques to interrogate neuronal circuits. Moreover, students acquire knowledge about how to design and analyze *in vivo* experiments accordingly and gain knowledge about goal-oriented learning methods.			
Contents	• Planning *in vivo* experiments in mice • Chronic multi-photon *in vivo* imaging in awake and anaesthetized mice • Current toolboxes for circuit interrogation • Virus-mediated expression systems and strategies • Designing head-fixed behaviour experiments • Immunohistochemical examination of fixed brain tissue			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Diseases of the CNS & approaches to investigate neuronal circuit dysfunctions in mice	4	2	60
	Seminar	• Part1/2: Designing *in vivo* experiments • Part2/2: Neuronal and behaviour data analysis		2	60
	Practical Course	• AAV injections in mice • Cranial window surgeries • Two-photon *in vivo* microscopy • Structural and functional imaging data analysis • Immunohistochemistry • Confocal microscopy		2	105

Examinations	Type of examination(s)	Graded/non-graded
	Final oral presentation	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars	graded/non-graded
	Full participation in practical course	Non-graded
	Final oral presentation	
Additional information	Recommended literature:	

	Handbook of In Vivo Neural Plasticity Techniques. A Systems Neuroscience Approach to the Neural Basis of Memory and Cognition. Edited by Denise-Manahan-Vaughan. Volume 28. ISBN: 978-0-12-812028-6 Emiliani V et al. 2015 All-optical interrogation of Neural Circuits; DOI: https://doi.org/10.1523/JNEUROSCI.2916-15.2015 Zhang Z et al. 2018 Closed-loop all-optical interrogation of neural circuits in vivo; DOI: https://doi.org/10.1038/s41592-018-0183-z Imaging in Neuroscience, a Laboratory Manual. Edited by Fritjof Helmchen and Arthur Konnerth. Series editor Rafael Yuste. CSHL Press 2011. ISBN 978-0-87969-938-3. This or another edition

Computational Neuroscience				UNIVERSITÄT BONN
Module Number WPM 32	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term
Person in charge of the module	Prof. Dr. Tatjana Tchumachenko, Prof. Dr. Raoul-Martin Memmesheimer, Prof. Dr. Dominik Bach, Prof. Dr. Lukas Kunz			
Teaching Unit offering the module	Department of Biology, University Hospital Bonn, Department of Psychiatry, Department of Epileptology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	The module presents a variety of fundamental models and methods from computational neuroscience. By solving daily exercises the students learn how to practically apply the acquired concepts. The course introduces the employed more advanced mathematical tools embedded into the different topics. Further there will be a pre-course teaching the required programming skills in python.			
Contents	• Dynamical systems in neuroscience - linear algebra, matrices and vectors, linear differential equations - linear stability concept - rate models in neuroscience - synaptic plasticity and learning • Spiking models - binary neurons - a model for associative memory: Hopfield networks - leaky integrate-and-fire neurons - the balanced state of cortical networks • Cognitive modeling - probability measures, integrals, distributions - instantaneous decision models from economics & psychology - dynamic decision models: drift-diffusion models, decision field theory • Classification with neurons - representational similarity analysis - pattern classification analysis - support vector machines - deep learning			
Prerequisites for participation	None			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture			2	60
	Seminar			1	40
	Practical Course			3	125

Examinations	Type of examination(s)	Graded/non-graded
	Written examination	graded
Study elements required as prerequisite for admission to the module examination	Completion of 50% of the exercises	graded/non-graded Non-graded
Additional information	Recommended reading: Thomas Trappenberg, Fundamentals of Computational Neuroscience 2002	

Mitochondrial Biology in neuronal function and disease

Module Number WPM 33	Workload 225 h	Extent 7.5 CP	Duration (Semester) 1	Offered Summer Term

Person in charge of the module	Prof. Dr. Thomas Becker
Teaching Unit offering the module	Institute of Biochemistry and Molecular Biology

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	2. Sem.

Learning Outcomes	The students will get an overview about state-of-the-art techniques to study mitochondrial functions and mitochondrial dynamics. A set of cells with different mutations affecting mitochondrial functions will be analyzed using a broad range of biochemical and cell biological assays. By combining these assays, the students will obtain an overview on how different mitochondrial functions such as respiratory activity, dynamics, protein import and protein quality control are interconnected and result in mitochondrial deficiency.
Contents	The following content will be covered by the practical course: • Isolation of mitochondria • Blue native electrophoresis to study mitochondrial protein complexes. • Activity assays of respiratory chain complexes • Membrane potential measurements • Studies of mitochondrial morphology • Protein-protein interaction studies
Prerequisites for participation	None

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Mitochondrial function for neurons	4	1	30
	Seminar	Current topics in mitochondrial research		1	30
	Practical Course	Methods to study mitochondrial biology		4	165

Examinations	Type of examination(s)	Graded/non-graded
	Oral presentation with written handout	graded

Study elements required as prerequisite for admission to the module examination		graded/non-graded
	Full attendance of seminars and lectures	Non-graded
	Practical course including a protocol and oral presentation in the seminar	

Additional information	

Introduction to Python for data analysis				UNIVERSITÄT BONN
Module Number WPM 34	Workload 75 h	Extent 1.5 CP	Duration (Semester) 1	Offered SS
Person in charge of the module	Pietro Verzelli/ Oliver Braganza			
Teaching Unit offering the module	IEECR			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	Basic knowledge of Python syntax and functionality and core packages for data analysis and visualization.			
Contents	• Intro to Jupyter Notebooks, IDEs • Intro Python (loops, variables, functions) • Core packages (Numpy, Pandas, Matplotlib, Seaborn) • Accessing folders (shell, OS)			
Prerequisites for participation	Laptop (if you do not have a laptop, please get in touch in advance; we will find one)			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture		20	0.5	16
	Seminar			0.5	16
	Practical Course			1.5	42

Examinations	Type of examination(s)	Graded/non-graded
	Project (submit a notebook)	Non-graded

Study elements required as prerequisite for admission to the module examination		graded/non-graded

Additional information	Optional course, no credit points

Elective Practicals (Compulsory practical training/lab rotations)

Neural Stem Cells				UNIVERSITÄT BONN
Module Number WPP 3	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Oliver Brüstle			
Teaching Unit offering the module	Institute of Reconstructive Neurobiology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Knowledge on neural and pluripotent stem cell biology, hands-on experience in genetic modification and controlled differentiation of stem cells and their use for cell replacement strategies in the central nervous system. In this course the students learn to plan and design experiments to solve developmental neurobiological issues (Bloom taxonomy: synthesis).			
Contents	• Pluripotent and neural stem cell culture • Genetic modification of stem cells • In vitro differentiation into neurons and glia • Direct conversion into neurons and glia • Differentiation analysis (RT-PCR, immunofluorescence) • Neural transplantation			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Stem Cell Biology	6	1.0	75
	Practical Course	Methods in neural stem cell biology		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral presentation	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars Full participation in practical course	graded/non-graded Non-graded

Additional information	Recommended Reading: Molecular Biology of the Cell, 7th ed. Bruce Alberts et al.; Garland Publishing. 2022. Principles of Neural Science 6th ed. Eric R. Kandel et al.; McGraw-Hill Education. 2021.

Molecular Neurobiology				UNIVERSITÄT BONN
Module Number WPP 4	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Thomas Becker			
Teaching Unit offering the module	Institute of Biochemistry and Molecular Biology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	By the end of the course students will have learned relevant techniques for the analysis of biochemistry and cellular biology of neuronal and non-neuronal cells.			
Contents	• Basics of cell culture of neurons and oligodendrocytes • Subcellular fractionation of brain or cultured cells to isolate particular membrane compartments • Lipid analysis of membranes of neuronal or non-neuronal cells. • Techniques of protein analysis (metabolic labelling, immunoprecipitaton, • Western blot analysis, basics of mass spectrometry)			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Neurochemistry	3	1.0	75
	Practical Course	Techniques for the analysis of neuronal and non-neuronal cells		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral Examination	graded

Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentations in seminar.	graded/non-graded Non-graded
Additional information	Recommended Reading: 1. Kandel, Schwartz, Jessel, Principles of Neural Sciences, McGraw Hill 2. Purves, Neuroscience, Sinauer Associates	

Neurophysics				UNIVERSITÄT BONN
Module Number WPP 7	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Klaus Lehnertz			
Teaching Unit offering the module	Department of Epileptology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students receive hands-on experience in the analysis of biomedical data with linear/nonlinear univariate, bivariate, and multivariate time series analysis techniques.			
Contents	• linear and nonlinear time series analysis methods for the characterization of complex dynamical systems • statistical tools • analysis of biomedical data (e.g. EEG, structural/functional MRI data)			
Prerequisites for participation	45 CP, B.Sc. Physics/Mathematics/Computer Science; Basics of programming language			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Basics of linear and nonlinear time series analysis	2	1.0	75
	Practical Course	Analysis of biomedical data		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Written test report	graded

Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentation	graded/non-graded Non-graded

Additional information	Recommended Reading: 1. Kandel, Schwartz, Jessel, Principles of Neural Sciences, McGraw Hill Niedermeyer, Lopes da Silva; Electroencephalography, Urban & Schwarzenberg 2. Kantz, Schreiber: Nonlinear time series analysis. Cambridge UP Pikovsky, Rosenblum, Kurths: Synchronization: a universal concept in nonlinear sciences. Cambridge UP. 3. Priestley: Nonlinear and nonstationary time series analysis, Acad. Press Other working materials will be provided.

Training in Neuroinflammation				UNIVERSITÄT BONN
Module Number WPP 8	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Harald Neumann			
Teaching Unit offering the module	Institute of Reconstructive Neurobiology (Dozent: Prof. Dr. Harald Neumann			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.

Learning Outcomes	Students receive elaborated hands-on experience in cell culture techniques and its molecular analysis of cells. Functional cellular and molecular methods are combined with immunocytochemistry, flow cytometry and confocal microscopy.
Contents	• Basics of cell culture and tissue analysis • Functional bio-assays related to neuroinflammation • Molecular analysis of cells and tissues samples • Flow cytometry (FACS) analyses of cells • Confocal imaging analyses of tissue
Prerequisites for participation	45 CP

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	lab notes, progress reports, literature discussion, presentation	1	1.0	75
	Practical Course	Cell culture and cell analysis techniques;		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral presentation	graded

Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course	graded/non-graded Non-graded
Additional information	Recommended Reading: Molecular Biology of the Cell, ed. Alberts; Bruce et al. Principles of Neural Science, ed. Kandel et al.; Janeway's Immunobiology, ed. Murphy et al	

Analyses of synapse physiology by super-resolution microscopy				UNIVERSITÄT BONN
Module Number WPP 10	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Sommer and Winter Term
Person in charge of the module	PD Dr. Gerald Seifert, PD Dr. Ronald Jabs			
Teaching Unit offering the module	Institute of Cellular Neurosciences			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students receive elaborated hands-on experience in modern sophisticated imaging techniques. Students learn in depth knowledge in immunocytochemistry and quantitative analyses of ultrastructural assembly in synaptic structures archived by new methods in light microscopy.			
Contents	• Application of immunohistochemistry combined with tissue clearing and subsequent expansion of labeled structures. • Training in confocal fluorescence microscopy • Ultrastructural analyses and quantification of synaptic proteins under different experimental conditions. • Exploration of synaptic structure and perisynaptic glia			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Introduction in synapse physiology and neuron-glia interaction	3	1.0	68
	Practical course	Expansion microscopy, Confocal fluorescence microscopy, Ultrastructural analyses of synaptic structures		7.0	332

Examinations	Type of examination(s)	Graded/non-graded
	final oral presentation	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars Full participation in practical course Written protocols	graded/non-graded Non-graded

Additional information	Recommended Reading: 1. Kandel, Schwartz, Jessel, Principles of Neural Sciences, McGraw Hill 2. Asano et al., 2018, Current Protocols in Cell Biology, 80, e56. doi: 10.1002/cpcb56 3. Wassie et al., 2019, Expansion microscopy: principles and uses in biological research, Nature Methods 16:33-41. doi: 10.1038/s41592-018-0219-4 4. Imaging Neurons, A Laboratory Manual, Cold Spring Harbour Laboratory Press

Molecular Mechanisms of Neurodegenerative Diseases				UNIVERSITÄT BONN
Module Number WPP 11	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Jochen Walter			
Teaching Unit offering the module	Department of Neurology			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.

Learning Outcomes	Students receive an introduction into current biochemical and cell biological methods in the investigation of neurodegenerative diseases (Alzheimer's disease and Poly-Q diseases).
Contents	• Cloning of relevant proteins into mammalian and bacterial expression vectors • Expression of relevant proteins in mammalian and bacterial cell culture systems • Protein extraction from mammalian and bacterial cells – subcellular fractionation • Protein analysis - western immunoblotting, immunoprecipitation • Analysis with immunocytochemical techniques – microscopy
Prerequisites for participation	45 CP

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Advances in research of neurodegenerative diseases	3	1.0	75
	Practical Course	biochemical and cell biological methods in neurodegenerative diseases		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Written test report	graded

Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentation	graded/non-graded Non-graded

Additional information	Recommended Reading: 1. Selkoe DJ. Alzheimer's disease: genes, proteins, and therapy. Physiol Rev 2001;81: 741-66. 2. Walter, J., C. Kaether, H. Steiner, and C. Haass: Molecular Biology of Alzheimer's disease: Uncovering the secrets of secretases. Curr. Opin. Neurobiol. 11, 585-590 (2001). 3. Alzheimer's Disease: Methods and Protocols (ed. N.M. Hooper) Methods in Molecular Medicine Series. Humana Press, Totowa, NJ, USA (2000). 4. Evert BO, Wüllner U, Klockgether T (2000): Cell death in polyglutamine diseases. Cell Tissue Research 301, 189-204 5. Evert BO, Araujo J, Vieira-Saecker A, de Vos R AI, Brunt ER, Harendza S, Klockgether T, Wüllner U. Ataxin-3 represses transcription through chromatin binding, interaction with histone deacetylase 3 and histone deacetylation. J Neurosci, 2006;26:11474-86.

Functional MRI for the Investigation of Cognitive Functions				UNIVERSITÄT BONN
Module Number WPP 12	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	PD Dr. Johannes Schultz			
Teaching Unit offering the module	Department of Neurology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students receive hands-on experience in the investigation of cognitive functions by applying functional MRI techniques. The method of MRI and especially functional MRI will be combined with the design of psychological experiments suited for these techniques.			
Contents	• Basics of MRI and functional MRI • Design of psychological experiments • Analysis of functional MRI data • Functional Neuroanatomy			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Basics of MRI and fMRI experiments	2	1.0	75
	Practical Course	fMRI analysis		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Written test report	graded
Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentation	graded/non-graded Non-graded
Additional information	Recommended Reading: 1. Scott A. Huettel. Functional Magnetic Resonance Imaging. McMillanKarl 2. Friston. Statistical Parametric Mapping: The Analysis of Functional Brain Images. Academic Press 3. Richard Frackowiak et al. Human Brain Function. Elsevier	

Molecular Mechanisms of Synaptic Function				UNIVERSITÄT BONN
Module Number WPP 16	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Susanne Schoch McGovern			
Teaching Unit offering the module	Institute of Neuropathology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students receive an introduction into current biochemical and cell biological methods in the investigation of synapse function.			
Contents	• Cloning of relevant proteins into mammalian and bacterial expression vectors • Expression of relevant proteins in mammalian and bacterial cell culture systems (Transfection, viral transduction) • Protein extraction from mammalian and bacterial cells • Protein analysis - western immunoblotting, analysis of protein-protein interactions • Analysis with immunocytochemical techniques – microscopy • Live cell imaging			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Advances in research of synapse function	3	1.0	75
	Practical Course	biochemical and cell biological methods in synapse function		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Written test report	graded
Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentation	graded/non-graded Non-graded

Additional information	Recommended Reading: 1. The architecture of an excitatory synapse. Chua JJ, Kindler S, Boyken J, Jahn R. J Cell Sci. 2010 Mar 15;123(Pt 6):819-23. 2. The synaptic vesicle cycle.Sudhof TC. Annu Rev Neurosci. 2004;27:509-47. 3. Assembling the presynaptic active zone. Owald D, Sigrist SJ. Curr Opin Neurobiol. 2009 Jun;19(3):311-8. Epub 2009 Apr 22. Review. 4. RIM proteins and their role in synapse function. Mittelstaedt T, Alvaréz-Baron E, Schoch S. Biol Chem. 2010 Jun;391(6):599-606. Redundant functions of RIM1alpha and RIM2alpha in Ca(2+)-triggered neurotransmitter release. 5. Molecular organization of the presynaptic active zone. Schoch S, Gundelfinger ED. Cell Tissue Res. 2006 Nov;326(2):379-91. Epub 2006 Jul 25. 6. Schoch S, Mittelstaedt T, Kaeser PS, Padgett D, Feldmann N, Chevaleyre V, Castillo PE, Hammer RE, Han W, Schmitz F, Lin W, Südhof TC. EMBO J. 2006 Dec 13;25(24):5852-63. Epub 2006 Nov 23.

Impact of mitochondrial DNA mutations on neurodegenerative diseases				UNIVERSITÄT BONN
Module Number WPP 18	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Wolfram S. Kunz			
Teaching Unit offering the module	Institute of Experimental Epileptology and Cognition Research			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students receive an introduction to mitochondrial genetics and learn basic techniques to investigate the relevance of mitochondrial mutations in neurodegenerative diseases.			
Contents	• DNA isolation from human tissues • Detection of mtDNA mutations in human samples by various PCR-based techniques • Detection and quantification of multiple mtDNA deletion by single-molecule PCR • mtDNA sequencing and deletion mapping			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Mitochondrial DNA mutations in neurodegenerative diseases	1	1.0	75
	Practical Course	mtDNA deletional spectra in human disease		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Written test report	graded
Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentation	graded/non-graded Non-graded
Additional information	Recommended reading: 1. What causes mitochondrial DNA deletions in human cells? Krishnan KJ, Reeve AK, Samuels DC, Chinnery PF, Blackwood JK, Taylor RW, Wanrooij S, Spelbrink JN, Lightowlers RN, Turnbull DM. Nat Genet. 2008; 40(3):275-9. 2. Mitochondrial DNA damage and the aging process: facts and imaginations. Wiesner RJ, Zsurka G, Kunz WS. Free Radic Res. 2006; 40(12):1284-94. 3. Repeats, longevity and the sources of mtDNA deletions: evidence from 'deletional spectra'. Guo X, Popadin KY, Markuzon N, Orlov YL, Kraytsberg Y, Krishnan KJ, Zsurka G, Turnbull DM, Kunz WS, Khrapko K. Trends Genet. 2010; 26(8):340-3. 4. Clonally expanded mitochondrial DNA mutations in epileptic individuals with mutated DNA polymerase gamma. Zsurka G, Baron M, Stewart JD, Kornblum C, Bös M, Sassen R, Taylor RW, Elger CE, Chinnery PF, Kunz WS. J Neuropathol Exp Neurol. 2008; 67(9):857-66.	

Epigenetics					
Module Number WPP 21	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term	
Person in charge of the module	PD Dr. Andreas Waha				
Teaching Unit offering the module	Institute of Neuropathology				
Applicability of the module	Study Program		Mode	Study Semester	
	MSc Neurosciences		core course	3. Sem.	
Learning Outcomes	Students receive hands-on experience in technologies for the detection of epigenetic modifications and the functional analyses of epigenetically regulated genes in glioma cells.				
Contents	• chemical modification of genomic DNA • assay design for targeted DNA methylation analysis • pyrosequencing for detection of DNA methylation • histological analyses of epigenetic modifications on histones and DNA • functional cell assays • glioma cell culture				
Prerequisites for participation	45 CP, Attendance of lecture „Basics of Epigenetics“ and Pr. Course „Detection of DNA Methylation“				
Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	lab notes, progress reports, literature discussion, presentation	1	1.0	75
	Practical Course	molecular and cell biological methods in glioma genetics and epigenetics		7.0	375
Examinations	Type of examination(s)			Graded/non-graded	
	Written test report			graded	
Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course			graded/non-graded Non-graded	
Additional information	Recommended Reading: Epigenetics: Jörg Tost, Caister Academic Press Norfolk, UK 2008 Dunn GP et al.: Emerging insights into the molecular and cellular basis of glioblastoma. Genes Dev. 2012 Apr 15;26(8):756-84				

Extracellular Human Electrophysiology				UNIVERSITÄT BONN
Module Number WPP 22	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Dr. Florian Mormann			
Teaching Unit offering the module	Department of Epileptology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will learn how to analyze single-neuron activity and local field potentials recorded from the brain of awake human subjects undergoing invasive epilepsy monitoring.			
Contents	• Electrophysiological recording techniques • Design of cognitive paradigms • Spike detection and spike sorting • Peri-stimulus time histograms • Data analysis and statistical evaluation			
Prerequisites for participation	45 CP, Basic programming skills (Matlab) are recommended.			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Advances in human neurophysiology	2	1.0	75
	Practical Course	Electrophysiology, signal analysis, spike sorting		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Written test report	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars	graded/non-graded
	Full participation in practical course	Non-graded
Additional information	Recommended reading: 1. Kandel, Schwartz, Jessel: Principles of Neural Sciences, McGraw Hill 2. Gazzaniga, Ivry, Mangun: Cognitive Neuroscience, 3rd Ed.,W.W. Norton & Company, New York 3. Quiroga RQ, Kreiman G, Koch C, Fried I. Sparse but not 'grandmother-cell' coding in the medial temporal lobe. Trends Cogn Sci. 2008; 12: 87-91. 4. Quiroga RQ. Spike sorting. Scholarpedia 2: 3583. (http://www.scholarpedia.org/article/Spike_sorting)	

Cellular Neurobiology of Epilepsy				UNIVERSITÄT BONN
Module Number WPP 23	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term, Sommer Term

Person in charge of the module	Dr. Peter Bedner		
Teaching Unit offering the module	Institute of Cellular Neurosciences		
Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.
Learning Outcomes	Students will receive hands-on experience with approaches and methods in epilepsy research. They will study changes in expression of key glial and neuronal proteins in human and experimental epilepsy. In addition, they will analyze epileptic seizure activity by EEG/behavioral monitoring in transgenic mice or mice treated with potential novel antiepileptic substances.		
Contents	• Mouse model of temporal lobe epilepsy • Patch clamp analysis and single cell RT-PCR • Analysis of gap junction-mediated astrocyte coupling by tracer diffusion assays • Analysis of seizure activity by EEG and video monitoring • Immunoblot analysis and Real-Time PCR • immunohistochemical staining and confocal microscopy		
Prerequisites for participation	45 CP		

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Advances in epilepsy research	2	1.0	75
	Practical Course	Astrocyte dysfunction in epilepsy		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral presentation	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practical course	graded/non-graded
	Written report (protocol)	Non-graded
Additional information	Recommended reading: 1. Bedner P & Steinhäuser C (2015) Crucial role for astrocytes in epilepsy. Morgan & Claypool Life Sciences. 2. Bedner P. et al. (2015) Astrocyte uncoupling as a cause of human temporal lobe epilepsy. Brain. 138:1208-1222.	

Optogenetics				UNIVERSITÄT BONN
Module Number WPP 26	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Heinz Beck			
Teaching Unit offering the module	Department of Epileptology, Laboratory of Experimental Epileptology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will gain knowledge in optogenetics combined with electrophysiological and behavioral techniques, what is turning out to be one of the most influential novel techniques to dissect the functional architecture of the brain, and to identify neuronal motifs underlying specific behaviors. Students will be introduced to optogenetic techniques and their application in combination with electrophysiological techniques.			
Contents	• Principles of optogenetic Actuators • Cell-type specific expression techniques for optogenetic actuators • Technologies to achieve light-based optogenetic Stimulation in-vitro and in-vivo • Combination of optogenetic techniques with patch-clamp techniques			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Seminar on Optogenetic Techniques	1	1.0	75
	Practical Course	Introduction to viral gene transfer Introduction to patch-clamp techniques		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral Examination	graded

Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentation	graded/non-graded Non-graded
Additional information		

Information processing by neuron-glia assemblies				UNIVERSITÄT BONN
Module Number WPP 30	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Summer and Winter Term

Person in charge of the module	Prof. Dr. Christian Henneberger (Dr. Kirsten Bohmbach, Dr. Petr Unichenko)
Teaching Unit offering the module	Institute of Cellular Neurosciences

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.

Learning Outcomes	Students will receive an introduction to the concepts of information processing by mixed cellular networks (i.e. neurons and astrocytes) and hands-on experience in their experimental investigation. The focus is on the hippocampus and its cognitive role. Methods include multiphoton fluorescence imaging and electrophysiology, their combinations, super-resolution microscopy and behavioral analyses.
Contents	• mechanisms of neuron-astrocyte signal exchange in the hippocampus and their relevance for synaptic transmission and its plasticity, for hippocampus-dependent cognitive processes and behaviors such as spatial navigation • research methods will be selected from: ○ multiphoton fluorescence imaging and its applications for studying astrocyte/neuron signaling (e.g. Ca^{2+} imaging) and structural plasticity ○ advanced imaging techniques of optical indicators (e.g. FRET, FLIM) and indicator development (e.g. in HEK cells, acute brain slices) ○ electrophysiological methods like the patch clamp technique ○ super-resolution microscopy (expansion microscopy) ○ introduction to behavioral analyses (e.g. spatial memory, machine-learning based analysis)
Prerequisites for participation	45 CP

Course Elements	Teaching Mode	Topic	Group size	SWS	Workload [h]
	Seminar	Information processing by neuron-glia assemblies: concepts and methods	2	1	75
	Practical course	Information processing by neuron-glia assemblies		7	375

Examinations	Type of examination(s)	Graded/non-graded
	final oral presentation	graded

Study elements required as prerequisite for admission to the module examination		graded/non-graded
	attendance of seminars full participation in practical course	non-graded

Additional information	Recommended reviews on the topic: K. Bohmbach, C. Henneberger, J. Hirrlinger (2023) Astrocytes in memory formation and maintenance. Essays Biochem. 67(1):107-117. A. Semyanov, C. Henneberger, A. Agarwal (2020) Making sense of astrocytic calcium signals — from acquisition to interpretation. Nat. Rev. Neurosci. 21(10):551–564. D. A. Rusakov, L. Bard, M. G. Stewart, C. Henneberger (2014) Diversity of astroglial functions alludes to subcellular specialisation. Trends Neurosci. doi: 10.1016/j.tins.2014.02.008.

Structural MRI in Clinical Research				UNIVERSITÄT BONN
Module Number WPP 31	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Theodor Rüber, MD			
Teaching Unit offering the module	Department of Epileptology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	At the end of the practical course, the student is supposed to independently handle the acquisition, preprocessing and analysis of structural MRI data and relate the results to questions of clinical neuroscience.			
Contents	Acquisition and advanced analysis of MRI-data in clinical research including scanning routines, tractography, tract-based spatial statistics, voxel-based morphometry and support machine vector programming.			
Prerequisites for participation	45 CP Interest in programming			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Basics of DTI acquisition, preprocessing, analysis and applications	1	1	75
	Practical Course	DTI analysis		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral exam	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars, full participation in practical course, final oral presentation	graded/non-graded Non-graded
Additional information	Course will involve patient contact	

Comparative Neuroanatomy				UNIVERSITÄT BONN
Module Number WPP 32	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Michael Hofmann			
Teaching Unit offering the module	Institute of Zoology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Knowledge about histological techniques to analyze the structure of the fish brain.			
Contents	Structural analysis of the hypothalamic visual relay system across actinoptrygian fishes.			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Neuroanatomy of the hypothalamus in fishes	1	1	75
	Practical Course	Neuroanatomical techniques		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Protocol	graded

Study elements required as prerequisite for admission to the module examination		graded/non-graded
		Non-graded
Additional information		

In Silico Brain Sciences				UNIVERSITÄT BONN
Module Number WPP 33	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Marcel Oberlaender			
Teaching Unit offering the module	Center for Advanced European Studies and Research (Caesar)			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	This module provides students with hands-on experience how to combine experimental and computational methods to study the relationships between neuronal structure and function in the living animal. They will gain insight into state-of-the-art research in fields of Neuroanatomy, Neurophysiology, Computational Neuroscience			
Contents	• Reconstruction of neuron morphologies • Histological preparation of brain tissue • Electrophysiological recordings of single neurons in vivo • Simulations of cellular function via multi-compartmental neuron models.			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar			1	75
	Practical Course			7	375

Examinations	Type of examination(s)	Graded/non-graded
	Protocol	graded
Study elements required as prerequisite for admission to the module examination	none	graded/non-graded Non-graded
Additional information	https://www.caesar.de/en/our-research/in-silico-brain-sciences/research-focus.html	

Imaging Synapses at Nanoscale Resolution				UNIVERSITÄT BONN
Module Number WPP 34	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term

Person in charge of the module	Prof. Dr. Dirk Dietrich		
Teaching Unit offering the module	Department of Neurosurgery		
Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.
Learning Outcomes	Introduction to novel imaging techniques and modalities revealing the nanostructural architecture of synapses.		
Contents	• Basic fluorescence microscopy, • fluorescence lifetime imaging (FLIM), 2P excitation, • Fluorescence resonance energy transfer (FRET) • Stochastic optical reconstruction microscopy (d-STORM) • 3D-Electron microscopy, focused-ion beam (FIB) milling and scanning EM, specimen preparation and embedding.		
Prerequisites for participation	45 CP		

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Concepts of Super-Resolution Microscopy, FLIM and Dual Beam Electron Microscopy	3	1	75
	Practical Course	Hands-on in 1 of 3: dSTORM, FLIM, FIB-SEM		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Written test report	graded
Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentation	graded/non-graded Non-graded

Additional information

Recommended Reading:

1. Wilhelm, B. G. *et al.* Composition of isolated synaptic boutons reveals the amounts of vesicle trafficking proteins. *Science* **344,** 1023–1028 (2014). PDF available on request
2. Lakowicz, J. R. Principles of fluorescence spectroscopy. (2009), PDF available on request.
3. Maglione, M. & Sigrist, S. J. Seeing the forest tree by tree: super-resolution light microscopy meets the neurosciences. *Nature Neuroscience* **16,** 790–797 (2013). PDF available on request.
4. Miranda, K., Girard Dias, W., Attias, M., de Souza, W. & Ramos, I. Three dimensional reconstruction by electron microscopy in the life sciences: An introduction for cell and tissue biologists. *Molecular Reproduction and Development* **82,** 530–547 (2015). PDF available on request.
5. Maco, B. *et al.* Correlative In Vivo 2 Photon and Focused Ion Beam Scanning Electron Microscopy of Cortical Neurons. *PLoS ONE* **8,** e57405–7 (2013).

Zebrafish Model / CNS Myelinisation				UNIVERSITÄT BONN
Module Number WPP 36	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term

Person in charge of the module	Prof. Dr. Benjamin Odermatt		
Teaching Unit offering the module	Institute for Anatomy, CNS Myelinisation		
Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.
Learning Outcomes	The students will learn about the Zebrafish as a transparent vertebrate model organism in (neuronal) developmental biology and physiology. They will use transgenic (fluorescent) reporter fish-lines and transiently injected morphant fish larvae for (optical) screenings. Students will learn different manipulation and analysis methods in/for zebrafish.		
Contents	• Handling of adult and larvae zebrafish. Manual Morpholino® (MO) injections into fertilized fish eggs. • Fluorescent in vivo microscopy of transgenic larvae zebrafish. • Different screenings (behavior/development/expression) • Documentation and analysis of treated fish larvae (≤ 5 dpf) and their controls		
Prerequisites for participation	45 CP		

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Lab seminars (Techniques, novel findings, progress reports)	1	1	75
	Practical Course	Practical fish and lab (analysis) work		7	375

Examinations	Type of examination(s)	Graded/non-graded
	final oral presentation	graded

Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course	graded/non-graded Non-graded
Additional information		

Aging and neurodegeneration				
Module Number WPP 37	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Daniele Bano			
Teaching Unit offering the module	DZNE			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Using different model systems, students will learn about how mitochondrial dysfunction and epigenetic mechanisms are involved in the alteration of signalling pathways contributing to longevity, neurodegeneration and neuronal function.			
Contents	Students will have the opportunity to • work with various model systems (e.g. different cell lines, C. elegans and tissue from transgenic mice • perform different biochemical analysis assays (e.g. Western blot, RT-PCR) as well as • immunohistechemical stainings and confocal imaging In addition to hands-on practical methods, students will attend scientific lectures and seminars.			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar		1	1	75
	Practical Course			7	375

Examinations	Type of examination(s)	Graded/non-graded
	Project report (approx. 15 pages)	graded
Study elements required as prerequisite for admission to the module examination	none	graded/non-graded Non-graded
Additional information		

Social Neuroscience				UNIVERSITÄT BONN
Module Number WPP 39	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	PD Dr. Johannes Schultz			
Teaching Unit offering the module	Institute of Experimental Epileptology and Cognition Research			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	2. Sem.
Learning Outcomes	What are the neural mechanisms underlying social interactions? In this module, students will learn about neural mechanisms in primates underlying the detection and identification of living agents, the perception and decoding of the social signals these agents send, and the decisions about interacting with these agents. Brief insights into disorders of social interactions found in psychiatric conditions will then be discussed. These topics will be presented in the lectures, developed in the seminars and students will be able to get hands-on experience with designing and performing social perception and decision experiments in the practical course.			
Contents	• Cognitive neuroscience of social perception and cognition • Dysfunctions of social perception and cognition • Research methods in social neuroscience (signal detection theory; metacognition; experimental psychology; classification methods) • Experimental design			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Social neuroscience	2	1.0	75
	Practical Course	Experimental social neuroscience		7.0	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral Examination or Project report	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practical course Presentation of relevant literature	graded/non-graded Non-graded
Additional information		

Computational Neuroethology				UNIVERSITÄT BONN
Module Number WPP 41	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Kevin Briggman			
Teaching Unit offering the module	Dept. of Computational Neuroethology, Center for Advanced European Studies and Research (caesar)			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will gain hands-on experience using zebrafish and/or frogs are used as model systems in neuroethology. Students will perform behavioral recordings, whole-brain multiphoton calcium imaging and electron microscopy-based connectomic experiments. Students will also be introduced to computational analysis methods to analyze the time series data they record as well as EM image segmentation using machine learning.			
Contents	• Free swimming and restrained behavioural recording • Multiphoton neuronal population imaging • 3D electron microscopy preparation and collection • Time series analysis and machine learning-based image segmentation			
Prerequisites for participation	45 CP,			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Seminar on Computational Neuroethology	2	1	75
	Practical Course		2	7	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral Examination	graded
Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentation	graded/non-graded Non-graded
Additional information	https://www.caesar.de/en/our-research/current-groups/computational-neuroethology/research-focus.html	

Virtual Reality Experimentation				UNIVERSITÄT BONN
Module Number WPP 42	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Niclas Braun			
Teaching Unit offering the module	Department of Psychiatry and Psychotherapy			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students receive basic knowledge and hands-on experiences in the development and conduction of (clinical) virtual reality experiments. Students will either work on their own VR project or collaborate in an existing VR project.			
Contents	- How to design, code (C#, Unity) and conduct virtual reality experiments - How to record, time-sync and real-time access physiological data streams during virtual reality experiments (based on LabStreamingLayer) - How to analyse psychophysiological data (e.g.: wireless EEG, EMG, EDA, HRV or Eyetracking), using common Matlab-packages such as EEGLAB or LEDALAB.			
Prerequisites for participation	45 CP, psychophysiological foreknowledge or scripting experiences (Matlab, C#, Python) are desirable			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Lab notes, literature research, progress reports, lab-internal project presentation	2	1	75
	Practical Course	Implementation of an own VR experiment		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral presentation	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars Full participation in practical course	graded/non-graded Non-graded
Additional information		

Neuronal Polarization and Axonal Regeneration				UNIVERSITÄT BONN
Module Number WPP 43	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term

Person in charge of the module	Prof. Frank Bradke		
Teaching Unit offering the module	German Center for Neurodegenerative Diseases (DZNE e.V.) Bonn		
Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.
Learning Outcomes	Students will gain hands on experience in state-of-the-art cell biological, molecular and imaging techniques to study neuronal polarization and mechanisms of axonal regeneration.		
Contents	• Hypothesis driven planning and design of experiments for research project • Cloning, colony cracking and transfection • Cell culture and life cell imaging • Imaging and data analysis • Application of techniques depend on individual working plan		
Prerequisites for participation	45 CP,		

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Current developments in neuronal polarization and regeneration (literature seminar)	1	1	75
	Practical Course	Execution of research project as designed in first part of the Module		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral exam	graded
Study elements required as prerequisite for admission to the module examination	Participation in practical course	graded/non-graded Non-graded
Additional information		

Functional Characterization of Neuronal Cell Types				UNIVERSITÄT BONN
Module Number WPP 44	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Sabine Krabbe			
Teaching Unit offering the module	German Center for Neurodegenerative Diseases (DZNE)			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will be introduced to different concepts of neuronal cell type diversity (molecular, anatomical, functional). They will gain knowledge about state-of-the-art techniques used for dissecting the contribution of diverse neuronal cell types to behaviour. Students will gain hands-on experience with imaging techniques at the single-cell level in behaving mice and related data analysis.			
Contents	• Diversity of neuronal cell types and approaches to cell type classification • Experimental design to dissect the functional contribution of diverse neuronal cell types to behaviour • Stereotaxic surgeries and cell type-specific targeting with viral vectors in transgenic mice • Deep-brain imaging at the single-cell level using miniature microscopes in freely-moving mice and 2-photon recordings in head-fixed animals • All-optical interrogation of neural circuits with combined imaging and optogenetic approaches • Introduction to analysis of deep-brain imaging data			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Diversity of neuronal cell types	1	1	75
	Practical Course	Deep-brain imaging techniques and data analysis	1	7	375

Examinations	Type of examination(s)	Graded/non-graded
	Written report or final oral presentation	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars Full participation in practical course Written report or final oral presentation	graded/non-graded Non-graded
Additional information	Recommended reading will be announced upon registration.	

Protein quality control mechanisms in mental health and disease				UNIVERSITÄT BONN
Module Number WPP 45	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Nils Gassen			
Teaching Unit offering the module	Depratent of Psychiatry			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students receive an introduction into protein quality control mechansims (e.g. autophagy, ubiquitin proteasomal system) and learn basic techniques to investigate the relevance of protein quality control in neuronal and psychiatric (patho-)physiology.			
Contents	• Basic protein-biochemical methods (protein-protein interactions, Western Blotting • Processing of human samples for protein detection • Basic cloning techniques and CRISPR • Cell culture work with primary cells and cell lines			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Protein quality control mechanisms in mental health	2	1	75
	Practical Course	Measuring protein quality control in cells and tissue	2	7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral presentation	graded
Course Elements	attendance of seminars	graded/non-graded
	full participation in practical course final oral presentation	Non-graded

Additional information
Klionsky DJ, Abdelmohsen K, Abe A, Abedin MJ, Abeliovich H, Arozena AA, et al. Guidelines for the use and interpretation of assays for monitoring autophagy (3rd edition). Autophagy. 2016;12(1):1–222. Häusl AS, Balsevich G, Gassen NC, Schmidt MV. Focus on FKBP51: A molecular link between stress and metabolic disorders. Mol Metab. 2019;29:170–81. Balsevich G, Häusl AS, Chen A, Uribe-Marino A, Dournes C, Meyer CW, Namendorf C, … Gassen NC*, Schmidt MV*. (*shared Senior Authors) Stress-responsive FKBP51 regulates AKT2-AS160 signaling and metabolic function. Nat Commun. 2017;8(1):1. Gassen NC, Niemeyer D, Muth D, Corman VM, Martinelli S, Gassen A, et al. SKP2 attenuates autophagy through Beclin1-ubiquitination and its inhibition reduces MERS-Coronavirus infection. Nat Commun. 18 2019;10(1):5770.

Mechanisms of epileptogenesis

Module Number WPP 46	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term

Person in charge of the module	Chair: Dr. Julika Pitsch Co-Chair: Prof. Dr. Susanne Schoch, Prof. Dr. Albert Becker
Teaching Unit offering the module	Dept. of Epileptology (Dr. Pitsch), Dept. of Neuropathology (Prof. Schoch, Prof. Becker)

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	2. Sem.

Learning Outcomes	Students will obtain detailed knowledge on studying epileptogenesis and functional consequences of autoimmune-mediated epilepsies by using classical molecular biological approaches as well as in vivo models. The lectures will provide an introduction into different epilepsy models as well as in the molecular and cellular mechanisms leading to a hyperexcitable in neuronal networks and neuropathological brain alterations. The lectures will also introduce the methods that are being used to study epileptogenesis and associated inflammatory processes. In the practical course, students will apply several techniques such as classical molecular, cellular and in vivo mouse model approaches. At the systems level, they will be introduced to perform and analyze cell biological approaches. Finally, they will explore mechanisms of epileptogenesis and the role of inflammation in in vivo models using EEG-recording, immunohistochemistry, mRNA-analyses and multi electrode array approaches (MEA). The seminars will cover the methodological background and primary literature in the field and will help students to effectively read scientific literature.
Contents	• animal models to study epileptogenesis • *omics analyses of human epileptic specimen • Screening analyses for classical auto-antibodies and new candidates in patients suspicious for limbic encephalitis • Analyzing the functional role of patient-derived auto-antibodies in epilepsy in vitro und in vivo • Analyzing synchronous network activity in vitro (multi electrode array; MEA) • CrispR-Cas systems to interfere with epileptogenesis • Generation of animal models to study limbic encephalitis • Neuropathology in experimental LE
Prerequisites for participation	None

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Mechanisms of epileptogenesis	6	1	75
	Practical Course	Experimental approaches to study epileptogenesis		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral examination	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars. Successful participation in practical courses and paper presentation.	graded/non-graded Non-graded

Additional information	Will be announced at registration.

Aging and cellular senescence				UNIVERSITÄT BONN
Module Number WPP 47	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Dan Ehninger			
Teaching Unit offering the module	German Centre for Neurodegenerative Diseases, Bonn			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	What are important biological mechanisms underlying aging? In this module, students will deal with basic mechanisms involved in aging and will participate in the development of novel research approaches, such as tools and methods to analyze *in-vivo* senescent cells across tissues. Students will gain knowledge and practical experience with cell culture- and tissue-based approaches to aging and cellular senescence. By the end of the module, students should be able to design and perform experiments, analyze data obtained from their own experiments and generate a written report / oral presentation to communicate their findings.			
Contents	The lab-based practical part of the course will cover methods used to tackle questions in the research area outlined above, such as cell culture, microscopy, tissue dissociation and processing of tissue samples, MACS and FACS-based cell analysis and separation, cell transfection, cell genome engineering, transgene expression, cellular assays, protein and gene expression analyses etc. In addition to the practical part, students will attend lectures and seminars.			
Prerequisites for participation	45 CP			
Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar		1	1	75
	Practical Course			7	375
Examinations	Type of examination(s)			Graded/non-graded	
	Oral presentation			graded	
Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practical elements of the course, project report			graded/non-graded Non-graded	
Additional information	Recommended Reading: Campisi, J., 2005. Senescent cells, tumor suppression, and organismal aging: good citizens, bad neighbors. Cell 120, 513-522. Childs, B.G., Li, H., van Deursen, J.M., 2018. Senescent cells: a therapeutic target for cardiovascular disease. J Clin Invest 128, 1217-1228				

Neural correlates of memory and imagination				UNIVERSITÄT BONN
Module Number WPP 48	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term

Person in charge of the module	Dr. Dr. Cornelia McCormick
Teaching Unit offering the module	Department of Neurodegenerative Diseases and Geriatric Psychiatry

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.

Learning Outcomes

Students will gain in-depth understanding of

- Theoretical accounts of memory and imagination
- Neuropsychological tools to assess memory and imagination
- Introspective cognitive functions
- Memory disruptions due to neurodegenerative dementias
- Disruptions of visual imagination in aphantasia
- Research methods in clinical neuropsychology: analysis of patient data, group comparisons, inferential statistical tests
- theoretical basis of functional MRI data collection and analysis

Contents

- Assessment of memory and imagination in patients with neurodegenerative dementias and related to aphantasia
- Rating of patients' memory reports
- Analysis of patient data
- Writing summary reports

Prerequisites for participation	45 CP

Course Elements

Teaching Mode	Topic	Group-size	SWS	Workload [h]
Seminar	Neuropsychological basis of Memory and imagination	2	1	75
Practical Course	Assessment of memory and imagination in patients and their data analysis		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral presentation	graded

Study elements required as prerequisite for admission to the module examination	Full participation of seminars and practical course	graded/non-graded Non-graded
Additional information		

Pharmacology & Metabolism				UNIVERSITÄT BONN
Module Number WPP 49	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter and Summer Term
Person in charge of the module	Prof. Alexander Pfeifer			
Teaching Unit offering the module	Institute of Pharmacology and Toxicology			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.

Learning Outcomes	The following contents will be covered by the practical: • Murine primary adipocyte isolation and culture • Human adipocyte cell culture • Pharmacological intervention of experimental model system • Ex vivo and in vitro metabolic measurements (including oxygen consumption, energy expenditure, lipolysis, mitochondrial function, etc.) • Data collection, analysis and interpretation
Contents	This module is dedicated to understanding and investigating how small molecular modulators can be used to specifically target prominent metabolic pathways using the mouse as an experimental animal model. Attendees will be introduced to murine animal handling, murine primary adipocyte isolation and in vivo, ex vivo and in vitro pharmacological experimentation with the model system. The practical work will be supported by institute seminars covering, among other, signal transduction metabolism and pharmacology.
Prerequisites for participation	45 CP, successful participation at the Neuropharmacology module (WPM 13)

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Metabolism	1	1	75
	Practical Course	Methods in Pharmacology		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Written report	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars	graded/non-graded
	Full participation in practical course	Non-graded

Additional information	Recommended reading: Rang & Dale's Pharmacology; Elsevier Goodman and Gilman´s: The Pharmacological Basis of Therapeutics; McGraw-Hill

Epileptic Micronetworks / Antiepileptic Phototherapy				UNIVERSITÄT BONN
Module Number WPP 51	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	PD Dr. Michael Wenzel			
Teaching Unit offering the module	Dept. of Epileptology / IEECR			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Depending on the research focus (Micronetworks, Phototherapy), students receive hands-on experience in cellular resolution in vivo fluorescence imaging in mouse models of encephalitis/epilepsy, immunohistochemistry, field electrophysiology, patch-clamp recording, optical interference methods such as optogenetics or light-activatable drugs.			
Contents	• Cellular resolution fluorescent in vivo imaging (mouse model) • Histological analysis of post-encephalitic brain tissue changes • Field electrophysiology (in vivo, in vitro) • Patch-clamp cellular recordings (in vitro) • Targeted light-based circuit interference, light-activated antiepileptic drugs			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Lab notes, progress reports, literature, discussion, presentation	1	1	75
	Practical Course	Imaging, molecular Methods, and Electro-physiology in epilepsy		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral examination	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminars	graded/non-graded
	Full participation in practical course	Non-graded

Additional information	Recommended reading: Kandel, Schwartz, Jessel: Principles of Neural Sciences, McGraw Hill Jasper's Basic Mechanisms of the Epilepsies Rossi et al., The Enlightened Brain: Novel Imaging Methods Focus on Epileptic Networks at Multiple Scales, Front. Cell. Neurosci. 2018, 12:82 Kramer & Cash, Epilepsy as a Disorder of Cortical Network Organization, The Neuroscientist 2012 18(4) 360 –372 Paz et al., Microcircuits and their interactions in epilepsy: Is the *focus* out of focus? Nat Neurosci. 2015 18(3) 351–359 Cela et al., Novel Optogenetic Approaches in Epilepsy Research, Front. Neurosci. 2018, 13:947 Hüll et al., In vivo photopharmacology, Chem. Rev. 2018, 118, 10710−10747

Animal navigation: Behaviour and sensory neuroanatomy				UNIVERSITÄT BONN
Module Number WPP 52	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Pascal Malkemper			
Teaching Unit offering the module	Max Planck Institute for Neurobiology of Behavior – Caesar			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	This module provides students with hands-on experience in behavioral neuroscience, with a focus on magnetic orientation. Depending on the projects running in the lab, the students combine behavioral and histological methods to gain insights into the neuronal basis of the magnetic sense in animals. They will gain insight into state-of-the-art research in fields of behavioral biology and functional neuroanatomy.			
Contents	• Histological preparation of rodent sensory organs • Immunohistochemistry on mole-rat and mouse neuronal tissues • 3D histology using tissue clearing • Fluorescence microscopy, Light sheet microscopy • Behavioural assessment of magnetic orientation under controlled conditions			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	progress reports, lab-seminar, literature on magnetic orientation	1	1	75
	Practical Course	Animal neuroethology	1	7	375

Examinations	Type of examination(s)	Graded/non-graded
	Protocol	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars and practical elements of the course, oral project report in the lab seminar series.	graded/non-graded Non-graded
Additional information	https://mpinb.mpg.de/en/research-groups/groups/neurobiology-of-magnetoreception/research-focus.html Recommended Reading: 1. Nordmann, G.C., T. Hochstoeger, and D.A. Keays, Magnetoreception—A sense without a receptor. PLoS biology, 2017. 15(10): p. e2003234. 2. Malkemper, E.P., et al., Neuronal circuits and the magnetic sense: central questions. Journal of Experimental Biology, 2020. 223(21). 3. Caspar, K.R., et al., Eyes are essential for magnetoreception in a mammal. Journal of the Royal Society Interface, 2020. 17(170): p. 20200513. 4. Burda, H., et al., Magnetoreception in mammals, in The Senses: A Comprehensive Reference (Second Edition). 2020, Elsevier. p. 421-444. 5. Nimpf, S., et al., A putative mechanism for magnetoreception by electromagnetic induction in the pigeon inner ear. Current Biology, 2019. 29		

Deep Brain Imaging and Neural Circuit Computation in Health and Disease				UNIVERSITÄT BONN
Module Number WPP 53	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Jan Gründemann, PhD			
Teaching Unit offering the module	Deutsches Zentrum für Neurodegenerative Erkrankungen (DZNE)			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will be introduced to different concepts of neural circuit computations based on deep brain imaging data during complex behavioral paradigms in freely moving mice. This module will allow students to gain experience with methods for neuronal population activity analysis and how changes in the neuronal code are linked to learning and memory as well as behavioral adaptations in health and disease.			
Contents	• Deep brain imaging using single- and two-photon imaging techniques. • Miniature microscope recordings in freely moving animals • Combined all-optical imaging and optogenetic tools • Large scale neural population analysis using data science and machine learning techniques • Behavioural phenotyping using markerless pose estimation • Scientific programming using Python			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Neural Circuit Computations	2	1	75
	Practical Course	Imaging and data science research project.	2	7	375

Examinations	Type of examination(s)	Graded/non-graded
	oral presentation.	graded

Study elements required as prerequisite for admission to the module examination	Attendance of seminar Full participation in practical course Written report or final oral presentation.	graded/non-graded Non-graded
Additional information	www.dzne.de/gruendemann	

Behavioural data analytics				UNIVERSITÄT BONN
Module Number WPP 54	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Dominik Bach			
Teaching Unit offering the module	IEECR			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.

Learning Outcomes	Students will gain insights into specific analytics for behavioural data as well as more general concepts usable for any data types. They will learn about programming languages, data analytics workflows from wrangling to modelling and visualisation, and study the underlying statistical methods. Students can choose from workflows based on Python, R/tidyverse, or Matlab. Data will be provided and include videos, movement trajectories, ANS effector recordings, and neuroimaging data.
Contents	• Coding: theory, practical training, coding styles, unit testing • Collaborative software development workflows • Data analytics workflows • (Generalised) linear mixed effects models • Bayesian statistics • Data visualisation • Workflow automation • Meta-science
Prerequisites for participation	45 CP, Basic knowledge of at least one programming language (not necessarily the one used in the module)

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Data analytics	2	1	75
	Practical Course	Data analysis		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final report	graded

Study elements required as prerequisite for admission to the module examination	Attendance	graded/non-graded
	Presentation	Non-graded

Additional information	Recommended reading: (1) For R-related projects: Wickham & Grolemund (2017). R for Data Science. Sebastopol CA: O'Reilly. Available online at https://r4ds.had.co.nz (2) For Python-related projects, see resources on https://wiki.python.org/moin/BeginnersGuide/NonProgrammers https://wiki.python.org/moin/BeginnersGuide/Programmers

Functional Neuroconnectomics: from active neurons to complex behavior				UNIVERSITÄT BONN
Module Number WPP 55	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Martin K. Schwarz			
Teaching Unit offering the module	Institute for Experimental Epileptology and Cognition Research (IEECR)			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will be introduced to molecular, tissue engineering, imaging, and behavioral tracking techniques to learn how active neurons can be identified within large neuronal networks and lead to complex behaviors. They will gain knowledge about "state of the art" techniques and concepts and get hands-on experience in these techniques.			
Contents	• rAAV-guided engram labeling techniques (Cal-Light, SomCal-Light, FLARE) • Tissue engineering (FluoClearBABB, ExM) • Large-field superresolution microscopy • AI-guided behavioral classification • Multifactorial behavioral classification			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Engram labeling/imaging using light sheet fluorescence microscopy		1	75
	Practical Course	Engram labeling techniques (Cal-Light, FLARE), tissue clearing, expansion and imaging, computational neuroethology		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral presentation	graded
Study elements required as prerequisite for admission to the module examination	Continuous attendance of seminars Written report Full participation in the practical course	graded/non-graded Non-graded
Additional information	Recommended reading will be announced upon registration	

Analysis and modification of epigenetically regulated genes involved in neurodegenerative and oncological processes				UNIVERSITÄT BONN
Module Number WPP 56	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term

Person in charge of the module	PD Dr. Bernd Evert		
Teaching Unit offering the module	Department of Neurology		
Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.
Learning Outcomes	Students receive hands-on experience into current molecular and cell biological methods for the detection of epigenetic modifications and the functional analyses of epigenetically regulated genes in cell models of neurodegeneration and glioblastoma.		
Contents	• CRISPR/Cas9 mediated genome editing in mammalian cell lines • CRISPRoff genome editing tools to modify activity of gene promoters • Cloning of promoter regions and relevant proteins into reporter gene and mammalian expression vectors • Reporter gene assays to measure activity of gene promoters or unknown DNA sequences using plate luminometer. • Chemical modification of genomic DNA for DNA methylation analysis • Pyrosequencing for detection and quantification of DNA methylation • Chromatin preparation and chromatin immunoprecipitation analysis • Standard PCR and quantitative reverse transcription PCR analysis • Transfection and expression of relevant proteins in mammalian cells • Western blotting for protein analysis		
Prerequisites for participation	45 CP		

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Lab notes, progress reports, literature, discussion, presentation	1	1	75
	Practical Course	Molecular and cell biological methods		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral examination	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars	graded/non-graded
	Full participation in practical course	Non-graded
Additional information	Recommended reading: - Hernández-Carralero E, Cabrera E et al. ATXN3 controls DNA replication and transcription by regulating chromatin structure. Nucleic Acids Res. 2023. - Stahl F, Denner P et al. Activators of alpha synuclein expression identified by reporter cell line-based high throughput drug screen. Sci Rep. 2021. - Schneider M, Vollmer L et al. Meclofenamate causes loss of cellular tethering and decoupling of functional networks in glioblastoma. Neuro Oncol. 2021. - Krauss S, Evert BO. The Role of MicroRNAs in Spinocerebellar Ataxia Type 3. J Mol Biol. 2019.		

Wearable sensor lab				UNIVERSITÄT BONN
Module Number WPP 57	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Chair: Prof. Dr. Björn Krüger Co-Chair: Dr. Johannes Müllers			
Teaching Unit offering the module	Dept. of Epileptology			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.

Learning Outcomes	Main Goal of this lab course is to enable students to plan, execute and analyse experiments using wearable sensors. To this end, students will learn the basics of the hardware and communication of the sensors, basics of time-series data, algorithmic approaches for data analysis, and foundations of machine learning techniques. Students will learn how a research question can be answered by capturing and analysing data.
Contents	• Coding: basic concepts, practical training, testing • Foundations of sensor technologies • Foundations of Bluetooth communication • Usage of advanced programming interfaces (APIs) • Analysis of time series data • Introduction to machine learning techniques
Prerequisites for participation	45 CP, scripting or coding experiences are desirable (Python, Matlab, C++)

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Lab notes, literature research, progress reports, lab-internal project presentation	1-3	1	75
	Practical Course	Implementation of an experiment with wearable sensors		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral presentation	graded

Study elements required as prerequisite for admission to the module examination	Full participation in practical course	graded/non-graded Non-graded
Additional information		

<table>
<tr><td colspan="5">Neurodevelopment and Molecular Heterogeneity in the Nervous System</td><td>UNIVERSITÄT BONN</td></tr>
<tr><td>Module Number
WPP 58</td><td>Workload
450 h</td><td>Extent
15 CP</td><td>Duration
(Semester)
1</td><td colspan="2">Offered
Winter Term</td></tr>
<tr><td>Person in charge of the module</td><td colspan="5">Prof. Dr. Sandra Blaess</td></tr>
<tr><td>Teaching Unit offering the module</td><td colspan="5">Institute of Reconstructive Neurobiology, Neruodevelopmental Genetics</td></tr>
<tr><td rowspan="2">Applicability of the module</td><td colspan="3">Study Program</td><td>Mode</td><td>Study Semester</td></tr>
<tr><td colspan="3">MSc Neurosciences</td><td>core course</td><td>3. Sem.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">Knowledge on mouse genetics and mammalian brain development and function, hands-on experience in analysis of brain tissue using protein and mRNA detection methods, imaging and
(semi-)automated image analysis. In this course, the students learn to plan and design experiments to solve developmental neurobiological issues (Bloom taxonomy: synthesis).</td></tr>
<tr><td>Contents</td><td colspan="5">• Tissue isolation and cryosectioning
• Immunofluorescent staining/Western blots
• Tissue isolation and cryosectioning
• Imaging (e.g. Confocal microscopy, Slide scanner etc.)
• (Semi-) automated image anaylsis (e.g. Fiji, machine learning based analysis)</td></tr>
<tr><td>Prerequisites for participation</td><td colspan="5">45 CP</td></tr>
<tr><td rowspan="3">Course Elements</td><td>Teaching Mode</td><td>Topic</td><td>Group-size</td><td>SWS</td><td>Workload [h]</td></tr>
<tr><td>Seminar

Practical Course</td><td>Brain development, neuromodulatory systems in the brain; progress reports & journal clubs
Methods for analyzing mouse models of brain development</td><td>1</td><td>1

7</td><td>75

375</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td rowspan="2">Examinations</td><td colspan="4">Type of examination(s)</td><td>Graded/non-graded</td></tr>
<tr><td colspan="4">Oral presentation</td><td>graded</td></tr>
<tr><td rowspan="2">Study elements required as prerequisite for admission to the module examination</td><td colspan="4" rowspan="2">Attendance of seminars
Full participation in practical course</td><td>graded/non-graded</td></tr>
<tr><td>Non-graded</td></tr>
<tr><td>Additional information</td><td colspan="5">Recommended reading: Development of the Nervous System, Dan H. Sanes, Thomas A. Reh and William A. Harris, 4th Edition, 2020, Academic Press</td></tr>
</table>

Blood vessels in the CNS – formation and function				UNIVERSITÄT BONN
Module Number WPP 59	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Carmen Ruiz de Almodóvar			
Teaching Unit offering the module	Institute for Neurovascular Cell Biology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will receive an introduction on vascular biology to then deep-in into the specific properties and functions of blood vessels in the central nervous system, in development, homeostasis and disease.			
Contents	• Vascular Biology and organotypic properties • How to investigate blood vessels in the CNS • Isolation of blood vessels and endothelial cells from the mouse CNS • Endothelial cell tube formation assay • Co-culture of endothelial cells and pericytes in 3D • In vitro blood brain barrier assay			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Vascular Biology and organotypic properties	1	1	75
	Practical Course	Methods to isolate and work with primary endothelial cells in vitro		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral presentation	graded
Study elements required as prerequisite for admission to the module examination	Attendance of seminars	graded/non-graded
	Full participation in practical course	Non-graded
Additional information	Recommended reading: https://doi.org/10.1161/STR.0000000000000431 DOI: 10.1038/nature17040 https://doi.org/10.1016/j.tcb.2017.12.002 DOI: 10.1146/annurev-cellbio-100818-125142	

Neurons and microglia in the context of neurodegeneration				
Module Number WPP 60	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Martin Fuhrmann			
Teaching Unit offering the module	DZNE			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will gain hands-on experience on fluorescent immuno-histochemistry, confocal microscopy and intra-vital microscopy (functional (Ca^{2+}-imaging) and structural (e.g. GFP, YFP, tdTomato) in different cellular compartments). Students will also be able to perform data analysis of these different modalities and behaviour experiments.			
Contents	• Experimental design strategies • Fluorescent immuno-histochemistry • Confocal Microscopy • Intra-vital Microscopy (e.g. two-photon, three-photon, 2P-STED, …) • Data analysis • Behaviour			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Lab-seminar on current topics of Neuroimmunology and Imaging		1	75
	Practical Course	Execution of a small research project as designed in the first part or in advance of the module		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral presentation	graded
Study elements required as prerequisite for admission to the module examination	Participation in practical course	graded/non-graded Non-graded
Additional information	Please ask in advance	

Hands-on rotation in computational neuroscience				UNIVERSITÄT BONN
Module Number WPP 61	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter and Summer Term
Person in charge of the module	Prof. Tatjana Tchumatchenko			
Teaching Unit offering the module	IEECR UKB			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will gain hands-on experience in computational analysis of dendritic and synaptic dynamics and neural circuits. Students will be able to perform data analysis, research model parameters and simulate the corresponding models.			
Contents	• Computational design strategies • Differential equations • Programming in Python • Data analysis			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Group -seminar on current topics of Computational Neuroscience.		1	75
	Practical Course	Execution of a small research project, which is designed during the module or in advance of the module. Oral presentation of the research results in the group seminar. Preparation of a written summary report about the research project.		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Final oral presentation	graded
Study elements required as prerequisite for admission to the module examination	Regular participation and active research work during the module.	graded/non-graded Non-graded
Additional information	Limited number of spots per semester. Please contact Prof. Tchumatchenko via email in advance if interested in completing this module.	

Auditory Neuroscience				UNIVERSITÄT BONN
Module Number WPP 62	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Laura Fröhlich			
Teaching Unit offering the module	Department of Otorhinolaryngology; Center for Audiology			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students obtain knowledge on basic audiology and neurotology. They conduct electrophysiological recording experiments (in patients, if possible) and apply the methods typically used in auditory neuroscience by engaging in a scientific research project. Students also gain insight in clinical audiology and hearing rehabilitation by cochlear implants.			
Contents	• Hearing and speech perception and associated disorders (e.g., hearing loss, deafness, tinnitus) • Vestibular function and associated disorders • Objective electrophysiological measures: auditory and/or vestibular evoked responses (ECochG, BERA, ASSR, CERA, VEMP) • Behavioural experiments (psychoacoustics) • Principles of hearing rehabilitation with neural prostheses, i.e., cochlear implants • Research methods in audiology/auditory neuroscience • Application of methodology (in patients, if possible) • How to design and conduct research projects			
Prerequisites for participation	45 CP			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Basics of audiology	1	1	75
	Practical Course	Methods in audiology; Participation in research project		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Written project report	graded

Study elements required as prerequisite for admission to the module examination	• Attendance of seminar and practical course • Preparation of project report and oral presentation in research seminar	graded/non-graded Non-graded
Additional information	We will assemble a handout after the seminar and provide classical and actual papers related to a specific project, which the students will participate in to apply the learned theory and techniques. The course involves patient contact.	

Translational neurooncology				UNIVERSITÄT BONN
Module Number WPP 63	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Summer and Winter Term
Person in charge of the module	PD Dr. med. Matthias Schneider, Dr. med. Anna-Laura Potthoff			
Teaching Unit offering the module	Department of Neurosurgery, Brain Tumor Translational Research Group			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students should gain insights into preclinical pharmacological studies in glioblastoma research. They will learn basic principles of culturing glioblastoma cell populations and organoids and will have the possibility to generate cell populations and organoids from fresh tumor material from glioblastoma material obtained from the operating room. Additionally, students will develop skills in experimental planning and fundamental laboratory techniques including immunofluorescence, western blotting, cell viability assessment and flow cytometric assessment of cell death. Live-cell imaging under treatment and subsequent morphology analysis of glioblastoma cells will also be conducted. Using these techniques, they will explore the effects of various drugs and drug combinations, including chemotherapy and gap junction inhibitors on glioblastoma cells and organoids.				
Contents	• Basics of monolayer glioblastoma cell culturing • Generation and culturing of human glioblastoma organoids • Immunochemistry, Western Blot, DNA/RNA isolation • Flow cytometry analysis of cell death and cell viability assays • Live-cell imaging and morphology analysis • Data analysis including statistics using ImageJ, FlowJo, GraphPad PRISM • Visualization of results using Microsoft Excel/Powerpoint or Adobe illustrator				
Prerequisites for participation	45 CP				
Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Experimental planning, literature research, progress report and presentations, data analysis	1	1	75
	Practical Course	Determination of treatment effects on glioblastoma cells and organoids		7	375
Examinations	Type of examination(s)			Graded/non-graded	
	Final oral presentation			graded	
Study elements required as prerequisite for admission to the module examination	Attendance of seminars. Full participation in practical course.			graded/non-graded Non-graded	
Additional information	https://www.ukbonn.de/neurochirurgie/forschung/onkologische-forschung/ Schneider et al. Meclofenamate causes loss of cellular tethering and decoupling of functional networks in glioblastoma. Neuro-Oncology, 2021. Potthoff et al. Inhibition of Gap Junctions Sensitizes Primary Glioblastoma Cells for Temozolomide. Cancers, 2019.				

Functional Omics of Brain Aging				UNIVERSITÄT BONN
Module Number WPP 64	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Dr. Dan Liu Prof. Dr. Dr. Monique M.B. Breteler			
Teaching Unit offering the module	Population Health Sciences, German Center for Neurodegenerative Diseases (DZNE)			
Applicability of the module	Study Program		Mode	Study Semester
	MSc Neurosciences		core course	3. Sem.
Learning Outcomes	Students will receive an introduction to multi-omics data analyses (i.e. (epig)enetics, transcriptomics, proteomics) in large-scale human cohort studies and will learn basic molecular epidemiological methods to investigate the role of omics in brain aging.			
Contents	• Overview of high throughput omics technologies in human cohorts • Quality control and pre-processing steps of the omics data • Data analysis and statistical evaluation (i.e. epigenome-wide association analysis, transcriptomic-wide association analysis, and proteomic-wide association analysis)			
Prerequisites for participation	45 CP. Basics of programming language			

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Overview of multi-omics data and quality control	2	1	75
	Practical Course	Omics data analysis		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Written report	graded

Study elements required as prerequisite for admission to the module examination		graded/non-graded
	Attendance of seminars Full participation in practical course Final oral presentation	Non-graded

Additional information

Recommend reading:

1. Valdes AM, Glass D, Spector TD. Omics technologies and the study of human ageing. Nat Rev Genet. 2013 Sep;14(9):601-7. doi: 10.1038/nrg3553. Epub 2013 Aug 13. PMID: 23938363.
2. Campagna MP, Xavier A, Lechner-Scott J, Maltby V, Scott RJ, Butzkueven H, Jokubaitis VG, Lea RA. Epigenome-wide association studies: current knowledge, strategies and recommendations. Clin Epigenetics. 2021 Dec 4;13(1):214. doi: 10.1186/s13148-021-01200-8. PMID: 34863305; PMCID: PMC8645110.
3. Brandes N, Linial N, Linial M. PWAS: proteome-wide association study-linking genes and phenotypes by functional variation in proteins. Genome Biol. 2020 Jul 14;21(1):173. doi: 10.1186/s13059-020-02089-x. PMID: 32665031; PMCID: PMC7386203.

Mapping neural circuits underpinning internal state-dependent behavior				UNIVERSITÄT BONN
Module Number WPP 65	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term

Person in charge of the module	Prof. Dr. Ilona Grunwald Kadow		
Teaching Unit offering the module	Institute of Physiology, Faculty of Medicine		
Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.
Learning Outcomes	upon successful participation students know/use at least two of the following learning outcomes: • Carry out experiments using the model systems Drosophila or mouse • analyze animal behavior with optogenetics, mutants, video analysis • interpret and develop the results and suggest further experiments • carry out some simple electrophysiology and/or imaging experiments		
Contents	Depending on the aim of the research project, different methods and questions will be in focus. For instance: • behavioral analysis in flies or mice using videotracking, matlab analysis, optogenetics etc. • histology of brain and/or gut, immunostainings, genetics with GAL4/UAS • confocal microscopy • Image analysis using ImageJ software • statistical analysis with different softwares • conceptual discussion and literature searches to understand and propose ideas, results, hypotheses • presentation of data in lab seminar		
Prerequisites for participation	45 CP		

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Weekly Data and journal club focused on Neurogenetics and behavior		1	75
	Practical Course	Neurogenetics and Behavior		7	375

Examinations	Type of examination(s)	Graded/non-graded
	• Internship report of ~ 20 pages including introduction, methods, results and discussion	graded

Study elements required as prerequisite for admission to the module examination	• general principles and some practical experience in neurobiology, genetics, molecular biotechnology is expected • Presentation of project and results in lab meeting	graded/non-graded Non-graded
Additional information		

Engrams in health and disease				UNIVERSITÄT BONN
Module Number WPP 66	Workload 450 h	Extent 15 CP	Duration (Semester) 1	Offered Winter Term
Person in charge of the module	Prof. Dr. Stefanie Poll			
Teaching Unit offering the module	Institute of Experimental Epileptology and Cognition Research (IEECR)			

Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	core course	3. Sem.

Learning Outcomes	Students will gain knowledge in rodent engram research and the methods used in the field. These comprise activity-dependent and temporally controlled "tagging" (i.e. labelling of engram cells), gain- and loss-of-function studies and *in vivo* imaging techniques. Moreover, besides the history of engram research, students will learn about the current state of engram research and its applications to study memory impairments in diseases of the CNS, esp. Alzheimer's disease
Contents	• History and current state of engram research • Techniques to target engrams in mice *in vivo* and *in situ* • Behavioral paradigms to probe learning and memory in mice • Engram manipulation approaches
Prerequisites for participation	45 CP

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Seminar	Current definition of the engram and applied research methods	1	1	75
	Practical Course	Engram labelling and manipulation techniques		7	375

Examinations	Type of examination(s)	Graded/non-graded
	Oral examination	graded

Study elements required as prerequisite for admission to the module examination	attendance of seminars full participation in practical course final oral presentation	graded/non-graded Non-graded

Additional information	Recommended review articles: Yuste, R., Cossart, R., Yaksi, E. Neuronal ensembles: Buildings blocks of neural circuits. *Neuron*, **Volume 112**, Issue 6, 875 – 892. DOI: 10.1016/j.neuron.2023.12.008 Josselyn, S., Tonegawa, S. Memory engrams: Recalling the past and imagining the future. *Science* **367**, eaaw4325(2020). DOI:10.1126/science.aaw4325 Josselyn, S., Köhler, S. & Frankland, P. Finding the engram. *Nat Rev Neurosci* **16**, 521–534 (2015). DOI: 10.1038/nrn4000

Master's Thesis

Master Thesis				UNIVERSITÄT BONN
Module Number MA	Workload 900 h	Extent 30 CP	Duration (Semester) 1	Offered Each Semester

Person in charge of the module	The chairman of the Board of Examiners Prof. Dr. Christian Henneberger, contact Dr. Silke Künzel (Course Coordinator)		
Teaching Unit offering the module	Institutes and departments of the teaching staff to the MSc program		
Applicability of the module	Study Program	Mode	Study Semester
	MSc Neurosciences	compulsory	4. Sem.
Learning Outcomes	The previously acquired knowledge and skills are to be practically applied in the context of a well-defined scientific problem		
Key Skills Qualification	• Key skills qualifications promoted by the thesis work are communication, project planning and management, calculation and interpretation skills, literature research, data evaluation, text processing, presentation, working towards targets and on deadlines, communicating own needs, accepting constructive feedback, systematic analysis of problems, process design and control. • Implementation of theoretical knowledge in a practical research project in a chosen field of study in neurosciences • Independent research project of the student • Written thesis about the research carried out in accordance with current scientific standards		
Contents	The Master Thesis is the final part of the studies. The students work in a laboratory environment in the scientific groups of the departments involved in the study program. Their work usually contributes to a project leading to a scientific publication.		
Prerequisites for participation	Minimum 75 credit points from previous examinations (including compulsory modules), registration of the project and approval by the Chairman of the Board of Examiners.		

Course Elements	Teaching Mode	Topic	Group-size	SWS	Workload [h]
	Master Project	Neurosciences	1		900

Examinations	Type of examination(s)	Graded/non-graded
	Certificate and grading by two supervisors	graded
Study elements required as prerequisite for admission to the module examination	Registration after consultation with the supervisors	graded/non-graded Non-graded
Additional information	Recommended reading: current literature	