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

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

1 Courses

a) Practical course: 8 SWS
b) Lectures and Workshop: 2 SWS
a) Seminar: 1 SWS

2 Intended Learning Outcomes

The students are able to explain the basic structural properties of proteins and their implications in protein misfolding, protein aggregation and neurodegeneration. They can explain and apply biochemical and biophysical methods for characterization of proteins and their (mis)folding and aggregation. Students can handle basic laboratory instruments independently and appropriately. They document their results in a protocol and interpret them in relation to the scientific literature.
The students are able to describe and apply the fundamental concepts and techniques of fluorescence-based immunohistochemistry. They can use these concepts for the identification of various cell types and brain structures and make judgments regarding physiological and development-related questions. Students can use advanced techniques in light and fluorescence microscopy and adequately develop and evaluate the resulting documentation. They will learn to employ state of the art image analyses tools. They will know how to study basic physiological properties of brain cells using different techniques such as dynamic ion imaging and properly record, store, analyze, and illustrate the experimental data obtained with the specific techniques presented. Students will learn to critically evaluate and interpret their experimental findings. They are able to give an informative overview of scientific questions, experimental design, results and interpretation of the performed experiments both in oral and in written form.

3 Content

(Physical Biology will cover 2 weeks; Neurobiology will cover 4 weeks of the course)

Lecture "Protein aggregation in neurodegenerative diseases"

Protein structure. Thermodynamics of protein folding. Protein misfolding and aggregation. Spectroscopy: Fluorescence and circular dichroism. The prion protein and prion diseases as an example for protein misfolding and seeding in neurodegeneration. Prion-like proteins in neurodegenerative diseases. Fundamentals of Alzheimer's disease and Parkinson's dis-ease. Mouse models of neurodegenerative diseases. Drug development for treatment of neurodegenerative diseases.

Lecture "Analysis of Brain Function and Dysfunction"

Development of selected brain regions (cortex, hippocampus, cerebellum). Maturation and function of neurons and glial cells in vertebrate brains and synapse formation. Molecular and cellular basis of neuronal and glial cell function, properties of glial cells and neuron-glia interaction. Basic concepts of extra- and intracellular ion homeostasis, extra- and intracellular ion signaling. Excitotoxicity and role of ion dysbalance in brain pathology and in brain ischemia. Glial cells as central elements in brain pathology.
Basics of light microscopy: optics and lenses, structure of a microscope, optical path, aberrations, types of microscopes. Basics of fluorescence microscopy and immunohistochemistry. Fluorochromes, illumination, artefacts. Cell-type-specific labeling of neural cells with diagnostic antibodies.

Workshop "Fluorescence microscopy and Imaging"

Basics of dynamic fluorescence imaging: Wide-field, confocal, multiphoton microscopy and FLIM. Superresolution microscopy: STED, SIM and PALM/STORM.

	Imaging with ion-sensitive fluorescent dyes and genetically-expressed sensors, ion-sensitive microelectrodes. General lab work, use of eLab-FTW, statistical analysis, presentation of data. **Practical course:** **Physical Biology: Seeding assays to elucidate pathological protein aggregation** *Protein aggregation assays:* Sample preparation of aggregation-prone proteins, fluorescence spectroscopy, CD spectroscopy, SDS-PAGE, design, execution and evaluation of seeding assays. *Cellular seeding assays:* Fundamentals of cell culture techniques, light and fluorescence microscopy, imaging, data acquisition, and analysis. **Neurobiology: Immunohistochemistry and Dynamic Cellular Imaging** *Immunohistochemistry:* Primary and secondary immunofluorescence, identification of neural cell types, determination of the maturation stages of glial cells and neurons, marking of functionally relevant membrane structures in neurons and glial cells. *Fluorescence microscopy*: Components of a light microscope, epifluorescence microscopy, confocal laser microscopy, camera-assisted documentation, image processing. *Cellular Imaging:* Dynamic life imaging of intracellular ion signals under physiological and pathophysiological conditions (e. g. calcium imaging, sodium imaging and/or imaging of pH dynamics). Measurement of extracellular ion changes using ion-selective microelectrodes. *Analysis:* Data analysis of given data sets/own data sets, statistics, arrangement of data in figures and presentation. **Recommended reading, lecture notes:** Imaging in Neuroscience and Development: A Laboratory Manual. Cold Spring Harbor Laboratory Press Development of the Nervous System. Sanes, Reh & Harris, Elsevier 2012. Additional scripts and other documents will be available electronically through ILIAS.
4	**Teaching methods** Lecture (face to face and/or virtual), Workshop (face to face training and/or virtual), Practical course (hands on and virtual), Seminar (face to face and/or virtual)
5	**Prerequisites** **Formal:** Successful completion of module 1; Proficiency in English level B2 of Common Euro-pean Framework of Reference for Languages (CEFR) **With regards to content:** Knowledge of cell biology, chemistry, physics, mathematics as well as basic knowledge of neurobiology required.
6	**Examination types** **Cumulative examination:** (1) Written examination about the contents of the module including lectures, workshops and practical protocols and strategies (70% of overall mark), (2) Physical Biology (10%): Experiment protocol (3) Neurobiology: Description of analyses by pictures and notes, performance of experiments and analysis (10% of overall mark) (4) Neurobiology: Presentation: drafting of project, graphical description of project, presentation and discussion (10% of overall mark)
7	**Requirements for award of credit points** Regular and active attendance at the practical course and virtual sessions. Successful completion of the practical courses. Oral presentation in a seminar with an accompanying written hand out.

	The final grade is calculated from the mark of the written exam (weigh 70% of final grade) and the description of analyses, performance of experiments and the presentation (weigh 30%).
8	**Module applicability (in other study courses)** The module is closely related to module 3a, especially when using immunohistochemistry or -cytochemistry in combination with fluorescence microscopy. The module is also used in Master Biology and Master Molecular Biomedicine.
9	**Assessment** The mark given will contribute to the final grade in proper relation to its credits.
10	**Module convenor and main lecturers** Prof. Dr. C. R. Rose, Dr. K. Kafitz, Prof. Dr. Dieter Willbold, Prof. Dr. Wolfgang Hoyer, Dr. Luitgard Nagel-Steger, Prof. Dr. Erdem Gültekin Tamgüney
11	**Further information** The regular attendance at the lectures and workshop is strongly recommended. The content of the lectures is prerequisite for the practical course and the seminar.