Module Descriptions

Master of Science Biophysics

Examination Regulations in the Version of: 2024

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Advanced Biophysics Seminar

Modules referring to Compulsory Area

Code	8832875597
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	each Semester
Coordinator	Prof. Jens Michaelis
Instructor(s)	Prof. Christof Gebhardt, Prof. Kay Gottschalk, Prof. Jens Michaelis
Allocation of study programmes	Biophysics M.Sc., compulsory module, 1st or 2nd semester
Recommended prerequisites	Basic knowledge of physics, biology and biochemistry
Learning objectives	No English version available yet.
Syllabus	Preparation and presentation of a scientific lecture on a topic from biophysics or soft matter physics.
Literature	No English version available yet.
Teaching and learning methods	Seminar (2 hours per week)
Workload	30 hours seminar (attandance) 60 hours talk preparation Total: 90 hours

Assessment	The module examination consists of completing an assignement on a given topic and and a graded and the graded oral presentation of the results and participation in the discussion.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Presentation of scientific results.

Biophysics Research Project

Modules referring to Compulsory Area

Code	8832874016
ECTS credits	15
Attendance time	*keine Angaben*
Language of instruction	English
Duration	1
Cycle	each Semester
Coordinator	Prof. Jens Michaelis
Instructor(s)	Professors in the Institute of Biophysics and the Institue for Experimental Physics.
Allocation of study programmes	Biophysics M. Sc., 3rd Semester
Recommended prerequisites	Basic experimental and theoretical skills from the subject and subject-related lab courses.
Learning objectives	Students who successfully passed this module • have learned to familiarize themselves with a special area of the current international research in biophysics. • can search and understand the international scientific literature (information competence). • know the rules of good scientific practice.
Syllabus	• Search of suitable scientific literature and elaboration of the theoretical foundations • Concrete planning of the research project in collaboration with a team and the supervisor • Accomplishment of experimental or theoretical preliminary investigation • Presentation of the research project and intermediate results in a group seminar
Literature	tba

Teaching and learning methods	Research project to be carried out in the Institute of Biophysics or the Institute for Experimental Physics at Ulm University.
Workload	450 hours e.g. 11 weeks full-time
Assessment	The grade of the module will be the grade of the written exam. No prerequisites are necessary for exam registration.
Grading procedure	The grade of the module will be the grade of the exam.
Basis for	Master's thesis

Biophysics Lab - A

Modules referring to Compulsory Area

Code	8832875607
ECTS credits	9
Attendance time	8
Language of instruction	No English version available yet.
Duration	1
Cycle	each Semester
Coordinator	No English version available yet.
Instructor(s)	No English version available yet.
Allocation of study programmes	No English version available yet.
Recommended prerequisites	No English version available yet.
Learning objectives	No English version available yet.
Syllabus	No English version available yet.
Literature	No English version available yet.
Teaching and learning methods	No English version available yet.
Workload	No English version available yet.
Assessment	The module examination consists of a graded participation in all phases of the laboratory course. The evaluation scheme will be announced at the beginning of the lab.
Grading procedure	The module grade is equal to the examination grade.

Basis for	No English version available yet.

Biophysics Lab - B

Modules referring to Compulsory Area

Code	8832876658
ECTS credits	6
Attendance time	6
Language of instruction	No English version available yet.
Duration	1
Cycle	each Winter Semester
Coordinator	No English version available yet.
Instructor(s)	No English version available yet.
Allocation of study programmes	No English version available yet.
Recommended prerequisites	No English version available yet.
Learning objectives	No English version available yet.
Syllabus	No English version available yet.
Literature	No English version available yet.
Teaching and learning methods	No English version available yet.
Workload	No English version available yet.
Assessment	The module examination consists of an ungraded participation in all phases of the laboratory course. The evaluation scheme will be announced at the beginning of the lab.
Grading procedure	The module is not graded.

Basis for	No English version available yet.

Biophysics Lecture Series

Modules referring to Compulsory Area

Code	8832877119
ECTS credits	6
Attendance time	5
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	No English version available yet.
Instructor(s)	No English version available yet.
Allocation of study programmes	Master Biophysics, 1st semester
Recommended prerequisites	Introductory Biophysics
Learning objectives	No English version available yet.
Syllabus	No English version available yet.
Literature	No English version available yet.
Teaching and learning methods	No English version available yet.
Workload	No English version available yet.
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. Participation in the examination requires an ungraded study achievement. The type, content and scope of the study achievement[s] will be announced in good time in the course information and the course catalogue. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.

Grading procedure	The module grade is equal to the examination grade.
Basis for	No English version available yet.

Master's Thesis

Modules referring to Compulsory Area

Code	8832880000
ECTS credits	30
Attendance time	*keine Angaben*
Language of instruction	*not specified*
Duration	1
Cycle	each Semester
Coordinator	*not specified*
Instructor(s)	*not specified*
Allocation of study programmes	*not specified*
Recommended prerequisites	*not specified*
Learning objectives	*not specified*
Syllabus	*not specified*
Literature	*not specified*
Teaching and learning methods	*not specified*
Workload	*not specified*
Assessment	*not specified*
Grading procedure	*not specified*
Basis for	*not specified*

Introductory Biophysics

Modules referring to Adaptation

Code	8832876656
ECTS credits	6
Attendance time	5
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Prof. Jens Michaelis, Prof. Christof Gebhardt, Prof. Kay E. Gottschalk
Allocation of study programmes	M.Sc. Biophysics, adaptation module, 1st semester.
Recommended prerequisites	-
Learning objectives	Students who have successfully completed the module, • understand the basic terms and concepts of biophysics. • are able to describe biophysical phenomena using simple physical models.
Syllabus	This module teaches the following subject-specific content: • Time and length scale in biophysics • Physics at low Reynolds numbers • Brownian motion and diffusion • Fluorescence microscopy and spectroscopy • Structure and mechanics of biomolecules • Polymer models and force spectroscopy • Protein folding • Membrane potential
Literature	• Phillips, Kondev, Theriot: Physical Biology of the Cell, Garland Science • Howard: Mechanism of Motor Proteins and the Cytoskeleton, Sinaur and Associates • Lakowicsz: Principles of Fluorescence Spectroscopy, Springer US • Berg: Random Walks in Biology, Princeton University Press

- Alberts: Molecular Biology of the Cell, Garland Science

Teaching and learning methods	Biophysics (lecture/seminar) (4 classroom hours per week) Laboratory (1 classroom hour per week)
Workload	Attendance: 90 h Private study: 90 h Total: 180 h
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants and an ungraded written elaboration. Participation in the examination requires an ungraded study achievement. The type, content and scope of the study achievement will be announced in good time in the course information and the course catalogue. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the graded examination.
Basis for	Advanced Biophysics Modules

Introductory Chemistry

Modules referring to Adaptation

Code	8832871944
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1 Semester
Cycle	each Winter Semester
Coordinator	The Dean of Studies of Chemistry
Instructor(s)	Dr. D. Bresser
Allocation of study programmes	Energy Science and Technology M. Sc., elective area A1 Biophysics M.Sc., adaptation module, 1st semester
Recommended prerequisites	Fundamentals in mathematics, physics and chemistry
Learning objectives	Students are able to • discuss a given chemical element with respect to its position in the periodic table of elements, structure of its electron shell and its ability to form chemical bonds. • describe the equilibrium of a given reaction according to the mass action law. • use the idea of the pH-value and the acid/base-pK_a/pK_b-value to analyze the properties of water, oxo-acids, weak acids and bases, buffers and indicators. • identify a redox reaction and analyze it with respect to the redox potential of the individual reactants and the difference in redox potential of the overall reaction.
Syllabus	• Structure of matter, states of matter, phase diagrams, separation techniques • Atom structure (qualitative): Bohr's atom model, hydrogen atom, isotopes, periodic table of the elements • Formation of chemical bonds, bond order, molecular orbital • Chemical bonding: Compounds with covalent bonds, inorganic salts, Van der Waals forces, Metals/semiconductors • Chemical reaction: Reaction equilibrium, mass action law, principle of LeChatelier • Water: Structure and properties, pH-value • Acids and bases: theories, pK_a- and pK_b-values, oxo-acids, weak acids and bases, buffers, indicators, titrations

	• Redox-reactions: Oxidation, reduction, oxidation numbers, redox potential, Nernst´s equation, • Selected large scale reactions • Organic chemistry nomenclature, functional groups, principle reactions
Literature	• Malone, Leo, J., Dolter, Theodore: Basic Chemistry, 9th Edition International Student Version, Wiley, 2012.
Teaching and learning methods	Lecture (2 hours/week)
Workload	Presence: 30 h Self study: 60 h Total: 90 h
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	All chemical modules

Mathematical Methods in Material Science

Modules referring to Adaptation

Code	8832872382
ECTS credits	5
Attendance time	4
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Dr. Ressa Said, Dr. Genko Genov
Allocation of study programmes	Quantum Engineering M.Sc., Biophysics M.Sc., adaptation module, 1st semester
Recommended prerequisites	None
Learning objectives	Students who successfully passed this module • have an overview on essential mathematical methods for the solution of generic problems in Physics. • have trained to analyze and solve physical problems quantitatively.
Syllabus	This course gives an overview of essential mathematical methods for the solution of generic problems in Physics. Specific examples of important physical applications will be given. The course aims to provide the student with the expected mathematical competency for further courses in different areas of Physics. • Application of complex numbers and variables • Fundamentals of matrices and its applications • Further differentials and integrals, differential equations • Fourier Series and Transform, Laplace Transform • Finite Difference and Spectral Solutions • Calculus of Variations

Literature	Bibliographical references will be given to the students for each different topic addressed in the course.
Teaching and learning methods	Lecture (3 hours per week), Exercise (1 hours per week)
Workload	45 hours lecture 15 hours exercise 90 hours self-study and exam preparation Total: 150 hours
Assessment	The grade of the module will be the grade of the written exam. No prerequisites are necessary for exam registration.
Grading procedure	The grade of the module will be the grade of the exam.
Basis for	All other modules

Practical Skills in Physics

Modules referring to Adaptation

Code	8832872383
ECTS credits	4
Attendance time	3
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Prof. Jens Michaelis
Instructor(s)	Dr. Carlheinz Röcker
Allocation of study programmes	Biophysics M.Sc., adaptation module for non-physics graduates, 1st semester
Recommended prerequisites	None
Learning objectives	Students who successfully passed this module • have practical experience in basic physical experimental techniques relevant to biophysics. • can analyze and evaluate experimental data. • are able to present the results in a suitable form and summarize them in a report.
Syllabus	Topics of experiments: • Mechanical oscillations • Thermic radiation • Optical interference and spectrometry • Oscillating electric circuits Students who have already covered the basic experiments in physics, may be advised to take other experiments from the Advanced Physics Lab.
Literature	-

Teaching and learning methods	Lab work with 4 full-day experiments including introductory and final discussions.
Workload	45 hours laboratory course (attendance time) 75 hours self-study, data analysis, report writing Total: 120 hours
Assessment	The grade of the module will be the grade of the oral exam. No prerequisites are necessary for exam registration.
Grading procedure	The grade of the module will be the grade of the exam.
Basis for	All other modules

Soft Matter Physics and Biophysics

Modules referring to Adaptation

Code	8832871164
ECTS credits	6
Attendance time	5
Language of instruction	English
Duration	1
Cycle	each Summer Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Prof. Dr. Christof Gehardt, Prof. Kay E. Gottschalk, Prof. Dr. Jens Michaelis
Allocation of study programmes	Physics M.Sc., elective module Physik B.Sc., elective module, 4th or 6th semester Wirtschaftsphysik M.Sc., elective module
Recommended prerequisites	Fundamentals of mechanics, optics and thermodynamics Attention: The module cannot be credited if the module "76025 Biophysics: Fundamentals" has already been successfully completed.
Learning objectives	Students who successfully passed this module • know the most important experimental methods to examine Soft Matter. • understand the physical fundamentals of living Condensed Matter. • can deal with and solve selected problems in the fields of Biophysics.
Syllabus	• The cell and its components • Biological macromolecules: proteins, nucleic acids, bio membranes • Transportation processes • Thermodynamics or structure formation in biological systems, equilibriums and reactions, cooperativeness • Function description of molecular machines • Model description of Polymers • Experimental techniques in biophysics: fluorescence spectroscopy and micrsocopy, force spectroscopy and microscopy • Experimental techniques in molecular biology: cloning and protein purification

Literature	• Philip Nelson: Biological Physics, Palgrave Macmillan; edition: Updated 1st e. (31. August 2007) • Robert Philips: Physical Biology of the cell, Taylor & Francis Ltd.; edition: 2nd edition. Revised. (21. November 2012)
Teaching and learning methods	Lecture (3 hours per week) Tutorials (1 hour per week) Block practical course (15 hours)
Workload	45 hours lecture (attendance) 15 hours tutorials (attendance) 15 hours practical course (attendance) 105 hours self-study and exam preparation Total: 180 hours
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. Participation in the examination requires an ungraded study achievement. If a specified academic work is achieved, a grade bonus is awarded in accordance with §17 (3a) of the General Examination Regulations at the immediately following examination. The examination grade is improved by one grade level, but not better than 1.0. An improvement from 5.0 to 4.0 is not possible. The type, content and scope of the study achievement[s] will be announced in good time in the course information and the course catalogue. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Research in the field of biophysics.

Cellular Biophysics

Modules referring to Biophysics Electives

Code	8832874005
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	each Summer Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Prof. Kay Gottschalk
Allocation of study programmes	Physics M.Sc., elective module, 1st or 2nd semester Biophysics M.Sc., elective module, 2nd semester
Recommended prerequisites	Principles of biophysics
Learning objectives	Students who have successfully passed this module • understand how cells interact with the environment. • are able to apply basic biophysical methods to current molecular and cell biological questions. • are able to describe biological phenomena with physical models of varying complexity.
Syllabus	The cell is the smallest living unit in the body. It fulfills a variety of specialized functions and interacts with the environment. Classically, biochemical interactions with the environment by soluble factors like hormones are considered. However, physical parameters like stiffness or shape also play an important role. The goal of the lecture is to highlight these physical triggers of cell function. The main topics are: • The cell as a composite material: structure and function of the cytoskeleton • Influence of cell shape on cell function • Mechanosignalling: Influence of substrate rigidity on cell function and mechanics • Measurement of cell mechanics: atomic force microscopy and microrheology • Measurements of cellular forces: traction force microscopy

Literature	• Phillips, Kondev, Theriot: Physical Biology of the Cell, Garland, 2013 • Alberts: Molecular Biology of the Cell, Garland Publishing, 2008
Teaching and learning methods	Lecture (2 hours/week)
Workload	30 hours: attendance time 60 hours: self study and exam preparation total: 90 hours
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Research in the field of biophysics

Gene Expression

Modules referring to Biophysics Electives

Code	8832874004
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	one-time
Coordinator	Prof. Dr. Jens Michaelis
Instructor(s)	Prof. Dr. Jens Michaelis
Allocation of study programmes	Physics M.Sc., elective module, 1st or 2nd semester Biophysics M.Sc., elective module, 2nd semester Wirtschaftsphysik M.Sc., elective module, 1st – 3rd semester
Recommended prerequisites	Module Biophysics: Fundamentals
Learning objectives	Students who successfully pass this module • understand complex experimental setups in modern Biophysics • can apply fundamental biophysical methods to current molecular and cell biological issues • are able to describe biological phenomena using physical models of varying complexity
Syllabus	• Molecular basics and structural Biology of gene expression • RNA polymerase as molecular motor • FRET studies of transcription dynamics • Simple model of gene expression I and II • Gene expression in bacteria- Live single cell experiments • Gene expression in eukaryotes- Live single cell experiments • Whole genome analysis – Methods and Applications • Transcriptome analysis, methods for real time information • Single cell RNA sequencing • Introduction to Optogenetics

Literature	• Phillips, Kondev, Theriot: Physical Biology of the Cell, Garland 2013 • Alberts: Molecular Biology of the Cell, Garland Publishing 2008 • Latchman: Gene control, Garöland Science 2010 • Armstrong: Epigenetics, Garland Science 2014 • Buc and Strick: RNA Polymerases as Molecular Motors, RSC Publishing 2009 • Selvin and Ha: Single-Molecule Techniques, Cold Spring Harbor Laboratory Press 2008 • Papers: special papers, see lecture slides for sources
Teaching and learning methods	Lecture (2 hours per week)
Workload	30 hours lecture (attendance time) 60 hours self-study and exam preparation Total: 90 hours
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Research in the field of Biophysics

Molecular Motors

Modules referring to Biophysics Electives

Code	8832874003
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Prof. Dr. Christof Gebhardt
Allocation of study programmes	Physics M.Sc., elective module Biophysics M.Sc., elective module Wirtschaftsphysik M.Sc., elective module
Recommended prerequisites	Fundamentals in biophysics or soft matter physics
Learning objectives	Students who have successfully completed this module • understand complex experimental setups in modern biophysics. • can apply fundamental biophysical methods to current molecular and cell biological issues. • are able to describe biological phenomena using physical models of varying complexity.
Syllabus	• Cytoskeletal molecular motors • Stepping mechanisms • Coupling of mechanical and chemical cycles • Force production: Powerstroke vs. Brownian ratchet • Filament polymerization • Force production of cytoskeletal filaments • Length control of cytoskeletal filaments by molecular motors • Force-induced cooperation of molecular motors • DNA-based molecular motors • Models of gene regulation • Molecular motors and hearing

Literature	• Phillips, Kondev, Theriot: Physical Biology of the Cell, Garland Science • Howard: Mechanism of Motor Proteins and the Cytoskeleton, Sinaur and Associates • Lakowicsz: Principles of Fluorescence Spectroscopy, Springer US
Teaching and learning methods	Lecture (2 hours per week)
Workload	30 hours lecture (attendance time) 60 hours self-study and exam preparation Total: 90 hours
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Research in the field of biophysics

Research Internship

Modules referring to Internship

Code	8832875595
ECTS credits	15
Attendance time	15
Language of instruction	English
Duration	1
Cycle	each Semester
Coordinator	Dean of Phyiscs Studies
Instructor(s)	All lecturers of the faculty of natural sciences.
Allocation of study programmes	Biophysics M.Sc. FSPO 2024, 3rd semester.
Recommended prerequisites	-
Learning objectives	The internship serves to gain subject-related knowledge and experience in current research.
Syllabus	The research internship covers the typical skills of a scientist, e.g. search of suitable scientific literature and elaboration of the theoretical foundations of the scientific work.
Literature	tba
Teaching and learning methods	The topic must be approved in advance by the examination board. The research internship is usually carried out in one of the institutes of the Faculty of Science. Alternatively, it can be carried out externally.
Workload	450 h e.g. 11 weeks full-time

Assessment	The module examination consists of a graded participation in all phases of the project. The evaluation scheme will be announced at the beginning of the project.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Master's thesis

3D Deep Learning

Modules referring to Specialization

Code	8832877083
ECTS credits	6
Attendance time	4
Language of instruction	english
Duration	1
Cycle	irregular
Coordinator	Prof. Dr. Timo Ropinski
Instructor(s)	Prof. Dr. Timo Ropinski
Allocation of study programmes	• Cognitive Systems, M.Sc., FSPO 2017/Special Subject/Perception • Informatik, B.Sc., FSPO 2021/Schwerpunkt Informatik • Informatik, M.Sc., FSPO 2021/Kernfach/Praktische und Angewandte Informatik • Informatik, M.Sc., FSPO 2022/Vertiefungsbereich Informatik/Praktische Informatik • Künstliche Intelligenz, M.Sc., FSPO 2021/Vertiefungsfach Künstliche Intelligenz/Perzeption, Interaktion und Aktion • Künstliche Intelligenz, M.Sc., FSPO 2022/Vertiefungsbereich Künstliche Intelligenz/Lernen und Wissen • Mathematical Data Science, M.Sc., FSPO 2021, compulsory elective modules in Application Sciences • Mathematics, M. Sc., FSPO 2024, compulsory elective modules in multidisciplinary subsidiary subject • Mathematics, M. Sc., FSPO 2024, compulsory elective modules in subsidiary subject Computer Science • Medieninformatik, B.Sc., FSPO 2021/Schwerpunkt Medieninformatik • Medieninformatik, M.Sc., FSPO 2021/Kernfach/Mediale Informatik • Medieninformatik, M.Sc., FSPO 2021/Kernfach/Praktische und Angewandte Informatik • Medieninformatik, M.Sc., FSPO 2022/Vertiefungsbereich Medieninformatik/Medieninformatik • Medieninformatik, M.Sc., FSPO 2022/Vertiefungsbereich Medieninformatik/Praktische Informatik • Software Engineering, B.Sc., FSPO 2021/Schwerpunkt Software Engineering • Software Engineering, M.Sc., FSPO 2021/Kernfach/Praktische und Angewandte Informatik • Software Engineering, M.Sc., FSPO 2022/Vertiefungsbereich Software Engineering/Praktische Informatik • Mathematics and Management, M. Sc., FSPO 2024, compulsory elective modules in Computer Science

Recommended prerequisites	We assume previous knowledge in computer science, but not necessarily in machine learning.
Learning objectives	Students will learn deep learning concepts in the context of computer graphics and visualization. After introducing basic concepts and architectures, encoder/ decoder architectures as well as point cloud learning architectures will be introduced. The taught concepts will be realized using TensorFlow.
Syllabus	Machine Learning can be found in almost all fields of computer science. This course teaches basic concepts of machine learning and how they are applied to computer graphics. This course covers the whole process of developping, training neural nets and also adapting complex models to new datasets. Learning from 3D points aka. point clouds as it is covered in this course, is a current research topic in the field of computer graphics. Students will thus first learn how to solve standard machine learning problems, before applying their know how to 3D data. All practical realizations will be made in Tensorflow, which is also introduced in the course.
Literature	• Ian Goodfellow and Yoshua Bengio and Aaron Courville: Deep Learning, MIT Press 2016.
Teaching and learning methods	3D Deep Learning (Übung) (2 SWS), 3D Deep Learning (Vorlesung) (2 SWS)
Workload	in presence: 60h pre- and postprocessing: 120h sum: 180h
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. Participation in the examination requires an ungraded study achievement. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	-

Advanced Microbiology

Modules referring to Specialization

Code	8832878007
ECTS credits	15
Attendance time	13
Language of instruction	English
Duration	1
Cycle	each Summer Semester
Coordinator	Prof. Dr. Bernhard Eikmanns
Instructor(s)	Prof. Dr. Bernhard Eikmanns
Allocation of study programmes	• Biochemistry, M.Sc., FSPO 2022/Compulsory elective area/Specialization III: Biology, Biochemistry, Chemistry & Biophysics • Biology, M.Sc., FSPO 2022/Compulsory elective area/Research focus Biology • Biology teaching degree, M.Ed., FSPO 2022/Compulsory elective area/Biology
Recommended prerequisites	Basic knowledge of the following content is required for attendance at the lecture: - Structure and function of prokaryotic cells - Systematics and phylogeny - Viruses - Funghi - Microbial genetics - Microbial growth - Energy metabolism of microorganisms - Biosynthetic potential of microorganisms - Adaptability of microorganisms - Influence of microorganisms on nature and human beings Knowledge of the following technical content is required for attendance at the practical course: Cultivation media - Preparation of cultivation media, e.g. complex media vs. minimal media vs. mineral media vs. selective media - Composition of typical minimal media (components providing C, O, H, N, P, S, Mg, Ca, …), carbon source(s), energy source(s), supplements (….) - Containments for media (tubes, flasks, Erlenmayer flasks, bioreactors), pH adjustment, pH stability

- preparation of solutions [e.g. 0.9 % sodium chloride (NaCl) solution, 1 M NaOH]; handling and personal
security measures
- disposal of critical solutions and of surplus of media

Steril work
- Sterilization of media and media components
- Sterilization of glassware/plasticware
- Decontamination of laboratory space/bench
- Sterilization vs. decontamination vs. disinfection
- equipment for steril work (clean bench, disinfectant, incubator, autoclave, B. burner)
- Autoclave: characteristics, handling and security measures
- How to avoid contamination of sterile equipment / material?

Bacterial differentiation
- Microscopy (size; morphology; cell number)
- Cell staining (Gram+ and Gram-)
- Physiological tests (carbon sources, aerobic/anaerobic growth; metabolic products)
- Prokaryotes / Eukaryotes / Viruses; Serotypes; pathogens vs. apathogens
- Use of antibiotics (targets of antibiotics); Enzymatic tests
- Molecular methods (16S rRNA)

Physiology and regulation
- How to discriminate dead cells from living cells (viable count; trypanblue or propidium iodide staining)
- Definition of microbial growth; how to show growth of microbial cells (cell number; optical density, cell dry
weight)
- Growth phases and growth parameter (growth rate)
- Glucose metabolism of Escherichia coli (aerobic and anaerobic / respiration and fermentation)
- Catabolite repression (lactose utilization; diauxic growth; lac operon)

Recombinant DNA
- Plasmids: characteristics, essential features (Ori, MCS, selection marker, gene)
- How to define a ”Gentically Modified Organism” (= GMO)
Transformation, Konjugation, Transduction
Mutagenesis (chemical, radiation, tailor made)
- How to identify / verify a GMO

Microorganisms in the service of man
- How to use microorganisms for production and biotransformation (examples)
- How to use microorganisms for food production and/or preservation (examples)
- Antibiotics

Requirements for participation in this module are:

- successful participation in a microbiology lecture amounting to at least three CPs, proven by passing a written or oral examination
- successful participation in a basic internship in microbiology, proven by a performance record

Learning objectives

Students who have successfully completed this module
- have in-depth knowledge of key topics in microbiology and molecular microbiology
- have expanded their specialist knowledge in the field of molecular microbiology to include original work from current research, also with a view to later presenting their own research results
- have gained experience in actively participating in the discussion of presentations
- have acquired skills and competencies for independent work in the field of microbiology with regard to the implementation of special methods and the master's thesis
- are able to workindividually on topics related to current research in the laboratory under supervision (and sometimes independently).

Syllabus

In the lecture, the following scientific content is conveyed (in bullet points): Structure and function of RNA: ribosomal RNA, transfer RNA, messenger RNA, small non-coding RNA, catalytic activity of RNA, RNA editing, regulation of transcription in prokaryotes (stages of regulation, components of a promoter, RNA polymerase, phases of the Transcription initiation (elongation, pausing, termination), translation (initiation, elongation, termination, biosynthesis of selenoproteins), retroviruses, RNA viruses, induction (positive and negative control), repression (positive and negative control), cAMP-dependent and cAMP-independent catabolite repression, catabolite repression in Gram-positive bacteria, end product inhibition, attenuation, autogenic control, 2-component systems, FNR-dependent regulation, sigma factor-dependent regulation, T-box-dependent regulation, antisense RNA-dependent regulation, retro-regulation, enhancers elements, DNA loop-dependent regulation, DNA topology-dependent regulation, DNA methylation-dependent regulation, mRNA stability-activity-dependent regulation, riboswitches, quorum sensing, regulation by rare tRNAs, stringent control, signaling molecules, regulation of phage lambda

The following, the technical and scientific content in the practical course is listed:
- Principles and methods of enrichment, isolation and characterization of microorganisms (e.g. lactic acid bacteria, enterobacteria)
- Ames test to detect possible carcinogens
- Serological and enzymatic detection of ß-galactosidase induction in Escherichia coli
- Cultivation of Ashbya gossypii and detection of substrate conversion and riboflavin formation in a mutant of this fungus and characterization of a key enzyme in riboflavin formation
- Growth, substrate turnover and glutamate production of Corynebacterium glutamicum as well as detection of key enzymes in glutamate formation
- Organization of safety and health protection in the laboratory: introduction to relevant laws and regulations (e.g. biological substances ordinance, genetic engineering law), to safety aspects and protective measures for activities in the laboratory (e.g. operating instructions) and to safe working; risk assessment.

In the seminar, current publications from the fields of metabolism and its regulation in prokaryotes, applied microbiology as well as pathogenicity and host defenses will be presented and the topics will be discussed.

Literature

- Madigan MT, Martinko JM (2018). Brock Biology of Microorganisms, 15. Auflage. Pearson Education, Inc., Upper Saddle River, USA oder 14. Auflage, USA 2015.
- Wagner R: Transcription Regulation in Procaryotes . Oxford University Press, Oxford, New York, USA 2000.

	- Antranikian G : Angewandte Mikrobiologie. Springer-Verlag Berlin Heidelberg New York 2006. - Wilson, Sahm, Stahmann, Koffas (2020). Industrial Microbiology, 1. Auflage. Wiley-VCH Verlag. - Fuchs, Eitinger, Heider, Kemper, Kothe, Overmann, Schink, Schneider, Unden (2017). Allgemeine Mikrobiologie 10. Aufl., Thieme Verlag.
Teaching and learning methods	• Advanced Microbiology (Advanced practical course) (9 classroom hours per week, 9 ECTS, no.: 18507), • Advanced Microbiology (Lecture) (2 classroom hours per week, 3 ECTS, no.: 18007), • Advanced Microbiology (Seminar) (2 classroom hours per week, 3 ECTS, no.: 18907)
Workload	Attendance: 195 h Private study: 255 h Sum: 450 h
Assessment	The module examination consists of a graded written examination, an ungraded participation in the seminar and an ungraded participation in all phases of the advanced practical course. The evaluation scheme will be announced at the beginning of the module.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Master's thesis in the field of microbiology

Advanced Skills in Life Sciences

Modules referring to Specialization

Code	8832878022
ECTS credits	9
Attendance time	6
Language of instruction	English
Duration	1
Cycle	each Semester
Coordinator	Prof. Dr. Anita Marchfelder
Instructor(s)	Prof. Dr. Anita Marchfelder, Prof. Dr. Lena Bayer-Wilfert, Prof. Dr. Jan Tuckermann, Prof. Dr. Rebekka Hufendiek, Dr. Vincent Doublet
Allocation of study programmes	Biology, M.Sc., FSPO 2022/Compulsory area
Recommended prerequisites	
Learning objectives	Seminar Scientific Integrity, Data Analysis & Management: You will learn principles of managing and analysing data using R; methods will cover linear models as well as generalised mixed models Lecture Molecular Biology and Biotechnology: Students who have successfully completed the lecture Molecular Biology and Biotechnology, • have in-depth knowledge regarding important aspects of modern molecular biology and biotechnology; • have an in-depth methodological knowledge of the most important basic techniques of general molecular biology and their use to elucidate complex relationships in the functioning organism; • are able to assess the limitations of molecular approaches using examples; • have competences to assess and reflect on application-related developments in genetic engineering at a scientifically up-to-date level with regard to the practical significance Seminar Philosophy of Science: Students who have successfully completed this module are familiar with the basic positions of contemporary philosophy of science, the debates over the definition of science and scientific methodology, realism and anti-realism, and the relationship

between science and values. They will be able to reproduce orally and in writing the issues and patterns of argumentation in philosophical debates.

Syllabus

Seminar Scientific Integrity, Data Analysis & Management:
- using R and R studio
- data management
- linear modles
-generalised mixed models

Lecture Molecular Biology and Biotechnology:

- Modern aspects of molecular biology and biotechnology including important techniques in molecular biology research.
- Current examples from applied biotechnology.

Seminar Philosophy of Science:

- What is science?
- Scientific inference
- Scientific explanation
- Realism and anti-realism
- Scientific change and scientific revolutions
- Philosophical problems in biology and the life sciences
- Science and values

Literature

Seminar Scientific Integrity, Data Analysis & Management:
- scripts and files (e.g. R-code) on moodle

Lecture Molecular Biology and Biotechnology:
Lewin´s Genes XII
Twelfth Edition | Jocelyn E. Krebs, PhD; Elliott S. Goldstein, PhD; Stephen T. Kilpatrick, PhD | © 2018, Jones and Bartlett Publishers, Inc, ISBN 9781284104493

Seminar Philosophy of Science:

- Carrier, Martin: Wissenschaftstheorie zur Einführung, Hamburg: Junius 2021.
- Douglas, Heather: Science, Policy, and the Value-Free Ideal, Pittsburgh, The University of Pittsburgh Press 2009.
- Godfrey-Smith, Peter: Theory and Reality: An Introduction to the Philosophy of Science, Chicago: University of Chicago Press 2021.
- Okasha, Samir: Philosophy of Science: A Very Short Introduction, Oxford: Oxford University Press 2016.

Teaching and learning methods

- Scientific Integrity, Data Analysis & Management (Seminar) (2 classroom hours per week, 3 ECTS, no.: 18522),
- Molecular Biology and Biotechnology (Lecture) (2 classroom hours per week, 3 ECTS, no.: 18015),
- Philosophy of Science (Seminar) (2 classroom hours per week, 3 ECTS, no.: 18022)

Workload	Attendance: 90 h Private study: 180 h Sum: 270 h
Assessment	The module examination consists of a graded written examination on the lecture Molecular Biology and Biotechnology, the ungraded participation in the seminar Data Analysis/Management, Scientific Integrity and the reading of given texts, the ungraded written elaboration and discussion in the seminar Philosophy of Science. The exact modalities will be announced at the beginning of the courses.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Compulsory elective area

Inorganic Materials Synthesis/Inorganic Nanomaterials

Modules referring to Specialization

Code	8832871300
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	each Summer Semester
Coordinator	The Dean of Studies of Chemistry Timo Jacob <timo.jacob@uni-ulm.de>
Instructor(s)	Prof. Dr. Mika Lindén
Allocation of study programmes	Master Chemistry, elective area B1 (Inorganic Chemistry) or B2 Master Chemistry and Management, electivearea B3 Master Energy Science and Technology, elective area B Master Teaching Chemistry, elective
Recommended prerequisites	Bachelor's competences in the field related to the subject
Learning objectives	Students who have successfully completed this module, - will learn important synthesis paradigms and advanced characterization techniques in relation to functional nanomaterials
Syllabus	This module provides the following content: - nanoparticle synthesis methods - film formation techniques - functional nanosystems - nanomaterial characterization
Literature	- Brinker & Scherer: Sol-Gel Science - Ozin: Nanochemistry

Teaching and learning methods	Seminar (2 hours per week)
Workload	Presence: 30 h Private study: 60 h Total: 90 h
Assessment	The module examination consists of a graded written exam.
Grading procedure	The module grade is equal to the examination grade.
Basis for	no data

Appropriate Medical Device Design

Modules referring to Specialization

Code	8832875312
ECTS credits	4
Attendance time	3
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Prof. Walter Karlen
Instructor(s)	Prof. Walter Karlen
Allocation of study programmes	Master Communications and Computer Engineering Master Electrical Engineering and Information Technology Master Communication and Information Technology Master Molecular and Translational Neuroscience Bachelor Computational Science and Engineering Master Biophysics
Recommended prerequisites	None
Learning objectives	At the end of the course, students can • name and describe the 4 main principles that define appropriate technology • apply these principles to critically analyse and assess health systems and technology • project him/herself into an unfamiliar person and environment • modify specifications of existing systems to improve appropriateness • discuss the challenges and illustrate the consequences of proposed design modifications • communicate effectively the results of his/her system analysis

Syllabus

This course elaborates upon relevant aspects in the conception, implementation and distribution of health devices and systems that effectively meet peoples and societies' needs in a local context. Four key elements of appropriateness (usage, cost, durability and performance) that are integral to the engineering design process are extensively discussed. Applications of point-of-care and mobile health devices to various user groups, such as the elderly or low income communities, are analysed.

The main **learning objectives** are to

- Evaluate the appropriateness of medical devices to the cultural, financial, environmental, and medical context in which they will be applied
- Design medical devices from a user's perspective for a specific context and health system

The course will be interactive and involve roleplay. Please do not sign up for this course if you are not ready to leave your comfort zone in class. The lectures are divided in two parts: The first part elaborates upon the important concepts of the design of health care devices and systems, and discusses implementation and dissemination strategies. We focus on communities such as low income households, the elderly, and patients with chronic illnesses that have special needs. Topics covered include point-of-care diagnostics, information and communication technologies, mobile health, user interactions, and also social-cultural considerations. The second part consists of elaboration of an appropriate device conducted by student groups. Each group will analyse an existing product or solution, critically assess its appropriateness according to the criteria learned in class, and provide explanations as to why the system succeeds or fails. The students will also present design improvements. The grade bonus will be based on a written case report due in the middle of the semester, the ungraded study achievement is a poster discussion and demo at the end of the semester.

Literature

- WHO, "Medical Devices: Managing the Mismatch", 2010.
- PATH, "The IC2030 report. Reimagining Global Health," 2015.
- R. Malkin and K. Von Oldenburg Beer, "Diffusion of novel healthcare technologies to resource poor settings," Annals of Biomedical Engineering, vol. 41, no. 9, pp. 1841:50, 2013.

Teaching and learning methods

Lecture: 1SWS

Exercise: 1SWS

Project: 1SWS

Workload

Active: 45

Prep & eval: 75

Sum 120

Assessment

The module examination consists of a graded written or oral examination, depending on the number of participants. If a specified academic work is achieved, a grade bonus is awarded in accordance with §17 (3a) of the General

	Examination Regulations at the immediately following examination. The examination grade is improved by one grade level, but not better than 1.0. An improvement from 5.0 to 4.0 is not possible. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	-

Bioinformatics and Systems Biology

Modules referring to Specialization

Code	8832872138
ECTS credits	6
Attendance time	6
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Prof. Dr. Hans Armin Kestler
Instructor(s)	Prof. Dr. Hans Armin Kestler, Prof. Dr. Michael Kühl, Prof. Dr. Franz Oswald, Dr. Karlheinz Holzmann, Prof. Dr. Enno Ohlebusch, Jun. Prof. Dr. Medhanie Mulaw, Dr. Alexander Groß, Dr. Johann Kraus, Dr. Ludwig Lausser, Dr. Axel Fürstberger, Dr. Sebastian Wiese, M.Sc. Robin Szekely
Allocation of study programmes	Molecular Medicine MSc, first semester
Recommended prerequisites	Basic knowledge of molecular biology and bioinformatics
Learning objectives	Students should be able to • describe the most important concepts in bioinformatics and systems biology. • apply, discuss and interpret state-of-the-art techniques out the field of bioinformatics and systems biology. • interpret basic mathematical networks and models
Syllabus	principles of molecular biology, data mining techniques, sequence alignment, phylogenetic inference and structural anaylsis, signal transduction, pathway analysis, modeling- and reconstruction techniques
Literature	• Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P.: Molecular Biology of the Cell, 6th Edition. Garland Science (2014) • Agostino, M.: Practical Bioinformatics, Garland Science (2013) • Draghici, S.: Statistics and Data Analysis for Microarrays Using R and Bioconductor. Chapman and Hall/CRC (2016) • Voit, E.: A First Course in Systems Biology, 2nd Edition. Garland Science (2017)

- Alon, U.: An Introduction to Systems Biology: Design Principles of Biological Circuits. Chapman & Hall/CRC (2020)
- Klipp, E. et al. Systems Biology: A Textbook, 2nd Edition. Wiley-VCH, (2016)

Teaching and learning methods	Seminar, exercises
Workload	~ 160 h (54h presence, ~108h self studies)
Assessment	The module examination consists of a graded written examination.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Master Molecular Medicine

Biomaterials

Modules referring to Specialization

Code	8832870999
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	The Dean of Studies of Chemistry
Instructor(s)	Prof. Dr. Anita Ignatius, Prof. Dr. Mika Lindén, Prof. Dr. Boris Mizaikoff, Prof. Dr. Alexander Kühne
Allocation of study programmes	Master Chemistry, elective area B1 (Inorganic Chemistry or Macromolecular Chemistry) or B2 Master Chemistry and Management, elective area B3 Master Teaching Chemistry, elective Master Biochemistry, elective
Recommended prerequisites	Bachelor's competences in the field related to the subject
Learning objectives	Students who have successfully completed this module • attain the understanding of biomaterials as materials that interfere with biological systems to measure, treat, support or replace a tissue, organ or physiological function. • are familiar with the various application areas of biomaterials. • possess knowledge for the preparation and characterization of biomaterials. • are able to explain and interpret the structural composition of biomaterials.
Syllabus	This module covers the following subject-specific topics: • Protein aggregates, amyloid and nanotechnology • Polymer-based and protein-based biomaterials • Polymer therapeutics • Directed transport of agents

Literature	Literature will be announced in the lecture.
Teaching and learning methods	Seminar (2 hours per week)
Workload	Attendance: 30 h Private study: 60 h Sum: 90 h
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade
Basis for	-

Biophotonics

Modules referring to Specialization

Code	8832871502
ECTS credits	6
Attendance time	6
Language of instruction	German or English
Duration	1
Cycle	each Summer Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Prof. Alwin Kienle
Allocation of study programmes	Physics M.Sc., elective module, 1st or 2nd semester Biophysics M.Sc., elective module, 2nd semester
Recommended prerequisites	Principles of Electrodynamics and Optics
Learning objectives	Students who successfully pass this module • understand the basics of Tissue Optics • know the medical applications of optical methods • are able to solve numerically differential equations with the Monte-Carlo method • are able to solve analytically differential equations in scattering problems with integral transforms
Syllabus	• Description of light propagation in scattering media based on Maxwell's equations, radiative transport theory and diffusion theory • Determination of the optical properties of scattering media • Light scattering from particles of different shapes • Colour origin in scattering media
Literature	
Teaching and learning methods	Lecture (3 hours per week)

	Laboratory course
Workload	45 hours lecture (attendance time) 45 hours laboratory course (attendance time) 90 hours self-study and exam preparation Total: 180 hours
Assessment	No english version available yet.
Grading procedure	No english version available yet.
Basis for	Research in the field of Biophysics

Biopolymers

Modules referring to Specialization

Code	8832871308
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	each Summer Semester
Coordinator	The Dean of Studies of Chemistry
Instructor(s)	Prof. Dr. Tanja Weil
Allocation of study programmes	Master Chemistry, elective area B1 (Organic Chemistry or Macromolecular Chemistry) or B2 Master Chemistry and Management, elective area B3 Master Biochemistry, elective Master Teaching Chemistry, elective
Recommended prerequisites	Bachelor's competences in the field related to the subject
Learning objectives	The students who have finished this module successfully, - have knowledge about the structure and function of nucleic acids, proteins and other biological macromolecules - know analytic methods that are used for characterization of this substance class
Syllabus	In this module the following contents are given: - structure and function of biopolymers, especially nucleic acids and proteins and some other natural products - physical and chemical characterization methods - structural regulation and chemical changes of biopolymers with regard to special applications

Literature	it is announced in the lecture
Teaching and learning methods	Lecture (2 hours per week) The lecture is currently offered as a combined version of Biopolymers and Introduction to Natural Products Chemistry.
Workload	Presence: 30 h Private study: 60 h Total: 90 h
Assessment	The module examination consists of a graded written or oral examination, depending on the numer of participants. The type of examination will be announced in time - at least 4 weeks prior to the date of the exam.
Grading procedure	The module grade is equal to the examination grade.
Basis for	No data

Causal Inference

Modules referring to Specialization

Code	8832874379
ECTS credits	4
Attendance time	3
Language of instruction	English
Duration	1
Cycle	irregular
Coordinator	Prof. Dr. Jan Beyersmann
Instructor(s)	Prof. Dr. Jan Beyersmann, lecturers of the Institute of Statistics
Allocation of study programmes	Finance, M.Sc., FSPO 2017, Specialization: Actuarial Science, compulsory electives in Mathematics Finance, M.Sc., FSPO 2017, Specialization: Financial Mathematics, compulsory electives in Mathematics Finance, M.Sc., FSPO 2017, Specialization: Financial Economics, compulsory electives in Mathematics Finance, M.Sc., FSPO 2021, Specialization: Actuarial Science, compulsory electives in Mathematics Finance, M.Sc., FSPO 2021, Specialization: Financial Mathematics, compulsory electives in Mathematics Finance, M.Sc., FSPO 2021, Specialization: Financial Economics, compulsory electives in Mathematics Artificial Intelligence, M.Sc., FSPO 2021, Special Subject Plan and Conclude Mathematical Data Science, M.Sc., FSPO 2021, compulsory electives in Mathematical Data Science Mathematics, M.Sc., FSPO 2018, compulsory electives in Applied Mathematics Mathematical Biometry, M.Sc., FSPO 2018, Advanced Methods of Biometry B Mathematical Biometry, M.Sc., FSPO 2018, compulsory electives in Mathematics and Statistics Mathematics and Management, M.Sc., FSPO 2018, compulsory electives in Stochastics, Optimization, Financial Mathematics
Recommended prerequisites	Introduction to Probability Theory and Statistics (Discrete random variables, stochastic concept of independence, parameter estimation, likelihood, confidence intervals, hypothesis testing, prediction)
Learning objectives	Students know the difference between statistical dependence and causality. They know statistical methods to draw causal conclusions on interventions based on observational data.

Syllabus	• Causal graphs and factorization • do()-calculus for discrete random variables • Counterfactuals
Literature	• Hernán MA, Robins JM: Causal Inference: What If. • Pearl: Causality
Teaching and learning methods	Causal Inference (lecture) (2 SWS), Causal Inference (exercise) (1 SWS)
Workload	• Classroom hours: 42 h • Individual study time: preparation and postprocessing (28 h), exercise (30 h), revision and exam (20 h) • **Total: 120h**
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	

Cellular Biophysics

Modules referring to Specialization

Code	8832874005
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	each Summer Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Prof. Kay Gottschalk
Allocation of study programmes	Physics M.Sc., elective module, 1st or 2nd semester Biophysics M.Sc., elective module, 2nd semester
Recommended prerequisites	Principles of biophysics
Learning objectives	Students who have successfully passed this module • understand how cells interact with the environment. • are able to apply basic biophysical methods to current molecular and cell biological questions. • are able to describe biological phenomena with physical models of varying complexity.
Syllabus	The cell is the smallest living unit in the body. It fulfills a variety of specialized functions and interacts with the environment. Classically, biochemical interactions with the environment by soluble factors like hormones are considered. However, physical parameters like stiffness or shape also play an important role. The goal of the lecture is to highlight these physical triggers of cell function. The main topics are: • The cell as a composite material: structure and function of the cytoskeleton • Influence of cell shape on cell function • Mechanosignalling: Influence of substrate rigidity on cell function and mechanics • Measurement of cell mechanics: atomic force microscopy and microrheology • Measurements of cellular forces: traction force microscopy

Literature	• Phillips, Kondev, Theriot: Physical Biology of the Cell, Garland, 2013 • Alberts: Molecular Biology of the Cell, Garland Publishing, 2008
Teaching and learning methods	Lecture (2 hours/week)
Workload	30 hours: attendance time 60 hours: self study and exam preparation total: 90 hours
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Research in the field of biophysics

Econophysics: Numerical Simulations

Modules referring to Specialization

Code	8832871657
ECTS credits	6
Attendance time	7
Language of instruction	German or English
Duration	1
Cycle	irregular
Coordinator	Dean of Physics Studies
Instructor(s)	Dr. Jürgen Stockburger
Allocation of study programmes	Physics M.Sc., elective module, 1st or 2nd semester Wirtschaftsphysik M.Sc., elective module, 1st - 3nd semester
Recommended prerequisites	Basic knowledge of Probability Theory
Learning objectives	Students who successfully pass this module • understand the theory of the numerical simulation of stochastic processes, and statistics of complex systems • are able to apply numerical simulation methods to complex systems
Syllabus	Integral and convergence concepts • Ito and Stratonowitsch integrals, Ito processes • concepts of convergence for random variables Numerical integration and differentiation • integration method with equidistant nodes • Gaussian integration • Taylor expansion and difference schemes Numerics for stochastic differential equations • explicit methods • Predictor-corrector methods

- numerical integration of stochastic differential equations

Random numbers and Monte Carlo simulations

- elementary MC method
- Metropolis algorithm
- MC simulation of large systems

Optimization methods and Control Theory

- numerical optimization methods
- Control Theory: optimization of dynamic systems
- algorithms for Control Theory

Literature	-
Teaching and learning methods	Lecture (3 hours per week) Exercise (2 hours per week)
Workload	45 hours lecture (attendance time) 30 hours exercise (attendance time) 105 hours self-study and exam preparation Total: 180 hours
Assessment	The grade of the module will be the grade of the oral exam. Prerequisite for exam registration is passing the pre-course (to be defined by the examiner).
Grading procedure	The grade of the module will be the grade of the exam.
Basis for	Research in the field of econophysics

Endocrinology

Modules referring to Specialization

Code	8832875427
ECTS credits	15
Attendance time	13
Language of instruction	English
Duration	1
Cycle	irregular
Coordinator	Prof. Dr. Jan Tuckermann
Instructor(s)	Prof. Tuckermann, Prof. Vujic-Spasic, Dr. Sabine Vettorazzi, Dr. Sooyeon Lee, Prof. Dr. Franz Oswald
Allocation of study programmes	• Biochemistry, M.Sc., FSPO 2022/Compulsory elective area/Specialization III: Biology, Biochemistry, Chemistry & Biophysics • Biology, M.Sc., FSPO 2022/Compulsory elective area/Research focus Biology
Recommended prerequisites	Content-related: - Formal: -
Learning objectives	Students who have successfully completed this module, • have in-depth knowledge of key topics in endocrinology and molecular endocrinology. • are able to independently develop a topic based on original publications and present it in a lecture. • are capable of in-depth practical work on a current research project in the field of molecular endocrinology.
Syllabus	The following technical content will be taught in this module: • Theoretical foundations of current research projects in molecular endocrinology, especially from the areas of signal transduction by nuclear

	receptors, hormonal control of iron homeostasis, signal transduction in RAS-MAPK developmental disorders, and hormonal regulation of macrophages in adipose tissue. • Application of cell biological, protein chemical and molecular biological working techniques. • Summary of results in a working protocol or poster and an oral presentation. • Independent conception of a small research project and preparation of an application for financial support.
Literature	• Kleine, B. und Rossmanith, W.G., Hormone und Hormonsystem: Lehrbuch der Endokrinologie, Springer Verlag, 3. Auflage (2014) • Current textbooks of biochemistry as well as physiology. • Subject specific literature
Teaching and learning methods	• Endocrinology (Seminar) (2 classroom hours per week, 3 ECTS, no.: 15427), • Endocrinology (Advanced practical course) (9 classroom hours per week, 9 ECTS, no.: 15427), • Endocrinology (Vorlesung) (2 classroom hours per week, 3 ECTS, no.: 15416)
Workload	Attendance: 195 h Private study: 255 h Sum: 450 h
Assessment	The module examination consists of the ungraded participation in all phases of the seminar and the advanced practical course including the writing of a grant proposal and a graded written or oral examination, depending on the number of participants. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Master thesis in the Institute of Comparative Molecular Endocrinology

Gene Expression

Modules referring to Specialization

Code	8832874004
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	one-time
Coordinator	Prof. Dr. Jens Michaelis
Instructor(s)	Prof. Dr. Jens Michaelis
Allocation of study programmes	Physics M.Sc., elective module, 1st or 2nd semester Biophysics M.Sc., elective module, 2nd semester Wirtschaftsphysik M.Sc., elective module, 1st – 3rd semester
Recommended prerequisites	Module Biophysics: Fundamentals
Learning objectives	Students who successfully pass this module • understand complex experimental setups in modern Biophysics • can apply fundamental biophysical methods to current molecular and cell biological issues • are able to describe biological phenomena using physical models of varying complexity
Syllabus	• Molecular basics and structural Biology of gene expression • RNA polymerase as molecular motor • FRET studies of transcription dynamics • Simple model of gene expression I and II • Gene expression in bacteria- Live single cell experiments • Gene expression in eukaryotes- Live single cell experiments • Whole genome analysis – Methods and Applications • Transcriptome analysis, methods for real time information • Single cell RNA sequencing • Introduction to Optogenetics

Literature	• Phillips, Kondev, Theriot: Physical Biology of the Cell, Garland 2013 • Alberts: Molecular Biology of the Cell, Garland Publishing 2008 • Latchman: Gene control, Garöland Science 2010 • Armstrong: Epigenetics, Garland Science 2014 • Buc and Strick: RNA Polymerases as Molecular Motors, RSC Publishing 2009 • Selvin and Ha: Single-Molecule Techniques, Cold Spring Harbor Laboratory Press 2008 • Papers: special papers, see lecture slides for sources
Teaching and learning methods	Lecture (2 hours per week)
Workload	30 hours lecture (attendance time) 60 hours self-study and exam preparation Total: 90 hours
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Research in the field of Biophysics

Introduction to Nuclear Magnetic Resonance

Modules referring to Specialization

Code	8832877108
ECTS credits	6
Attendance time	5
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Dr. Raiker Witter
Allocation of study programmes	Physics M.Sc., D - Examination Field Master Programmes, E - Examination Field General Range of Studies, 1st or 2nd semester
Recommended prerequisites	physical chemistry; QM II, atom and molecule physics
Learning objectives	Students who successfully passed this module: • are aware of and understand the wide scope, applicability and perspective of NMR spectroscopy across different fields (physics, chemistry and bio-medicine); • have comprehended the Hamiltonian concerning the interactions between electrons and nuclei in context of an external magnetic field (quantum mechanical/chemical approaches incl. perturbation theory); • know the quantum mechanical framework to understand, describe, and simulate NMR experiments incl. spectra; • have the basic understanding to interpret spectroscopic findings, material characterisations up to 3D structure determinations and imaging; • are able to combine the methodology to EPR, Nano-Sensing and Quantum Computing; and • are able to practically apply the knowledge to advance in other physics subjects (atom/molecule, solid-state and quantum information physics), scientific fields (organic, biomedical, inorganic, physical chemistry) and the wide scope of master theses in natural sciences.
Syllabus	The following technical contents are taught in this module:

(1) introductory: Stern-Gerlach experiment, Rabi experiment, NMR related noble prices;

(2) theoretically: the spin, wave-function, Schrödinger Equation, electrons-nuclei Hamiltonian with magnetic field incl. perturbation theory), Liouville von Neumann Equation, density operator/matrix, time-evolution operator (propagator), equilibrium vs. excited states, multi-quantum coherences, observation/truncation, rotating frame, average Hamiltonian, irreducible tensor formalism, relaxation (fluctuation, autocorrelation, spectral density, transition rates and relaxation times), product operator formalism, etc.;

(3) experimentally: basic setup (magnetic field incl. gradients, inductive detection, resonance circuit, duplexer, quadrature detection, ADC and computer), signal-to-noise, pulsed experiments, Fourier transformation, spectral fitting, signal assignment, referencing, magic-angle-spinning, rotor-synchronicity, ex-situ, in-situ, operando characterizations incl. basic MRI etc.; and

(4) applied: finally, an entrance to liquid- and solid-state NMR will be given by providing representative examples in organic, biomedical (3D structure determination) and inorganic chemistry (e.g. characterization of battery materials and devices).

Furthermore, a comprehensive introduction into dynamic nuclear polarization (DNP), electron spin resonance (EPR), quantum-sensing and quantum computing will be provided.

Literature

- Understanding NMR Spectroscopy; James Keeler, Wiley, 2010
- Quantum Mechanics Vol. 1 & 2, C. Cohen-Tannoudji et al., 1977
- Spin Dynamics, M. H. Levitt, 2008
- Principles of Magnetic Resonance, C. P. Slichter, 1978
- Principles of Nuclear Magnetism, A. Abragam, Clarendon Press, 1983
- Introduction to Solid-State NMR Spectroscopy, Melinda J. Duer, John Wiley & Sons, 2005
- Applications of NMR Spectroscopy, Atta-ur-Rahman and M. Iqbal Choudhary, Bentham, 2015
- Electron Paramagnetic Resonance Spectroscopy: Fundamentals, Patrick Bertrand, Springer, 2020
- Handbook of High Field Dynamic Nuclear Polarization, Vladimir K. Michaelis et at., Wiley, 2020
- NMR Quantum Information Processing, Ivan Oliveira et al., Elsevier Science, 2011
- Lectures on General Quantum Correlations and their Applications (Quantum Science and Technology), Felipe Fernandes Fanchini et al., Springer, 2017
- Electron Spin Resonance (ESR) Based Quantum Computing (Biological Magnetic Resonance Book 31), Takeji Takui, Lawrence Berliner et al., 2016

Teaching and learning methods

lecture (3 hours per week) with problem sheet solving and seminar (2 hours per week) for solutions' presentation incl. Q&A session (2 h/w).

Workload	45 hours lecture (attendance time) 30 hours seminar (attendance time) 105 hours self-study Total: 180 hours
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. Participation in the examination requires an ungraded study achievement. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	It can be considered being a versatile basis for a wider range of follow-up topics, incl. master theses, also beyond NMR, due to the fact that this spectroscopy is presented in it’s over decades and noble prices developed overarching character, providing settled synergies from theory, experiment to applications in physics, chemistry and biomedicine.

Laser Spectroscopy

Modules referring to Specialization

Code	8832871204
ECTS credits	4
Attendance time	3
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	The Dean of Studies of Chemistry
Instructor(s)	Prof. Dr. Thorsten Bernhardt
Allocation of study programmes	Master Chemistry, elective area B1 (Physical Chemistry) or B2 Master Chemistry and Management, elective area B3 Master Teaching Chemistry, elective
Recommended prerequisites	Bachelor's competences in the field related to the subject
Learning objectives	The students who have finished this module successfully, - dispose of the understanding of the physical bases of the laser - have an overview to well-chosen modern laser uses in the chemistry - own the skill to prepare a talk on the subject Laser spectroscopy independently and to report
Syllabus	In this module the following contents are given: - Derivation of the Planckschen of radiation sentence - Nitrogen laser - Laser rate equations - laser threshold - Colouring laser - Line forms, homogeneous - inhomogenous widening

- Coherence
- Laser fashions
- Light matter interaction
- Transitional dipole moment
- Born-Oppenheimer approximation
- Franck's Condon principle
- Laser spectroscopy of big molecules (basic ideas)
- Selection rules for big molecules
- Jablonski diagramme
- Femtochemie - coherence, potential surfaces, wave packages
- Non-beaming (not adiabatische) processes and photochemistry
- Laser spectroscopy in molecular rays
- Production of fs-laser pulses
- LIDAR
- Two-photon microscopy

Literature	- Telle, Urena, Donovan: "Laser Chemistry: Spectroscopy, Dynamics and Applications" - Eugene Hecht: "Optik"
Teaching and learning methods	Seminar and class (2+1 hours per week)
Workload	Presence: 45 h Private study: 75 h Total: 120 h
Assessment	The module examination consists of a graded written or oral examination, depending on the numer of participants. The type of examination will be announced in time - at least 4 weeks prior to the date of the exam.
Grading procedure	The module grade is equal to the examination grade.
Basis for	-

Learning Systems I: Introduction to Machine Learning

Modules referring to Specialization

Code	8832874212
ECTS credits	6
Attendance time	4
Language of instruction	englisch
Duration	1 Semester
Cycle	irregular
Coordinator	Prof. Dr. Dr. Daniel Braun
Instructor(s)	Prof. Dr. Dr. Daniel Braun
Allocation of study programmes	• Informatik, M.Sc., FSPO 2014/Kernfach/Praktische und Angewandte Informatik • Informatik, M.Sc., FSPO 2014/Vertiefungsfach/Mustererkennung • Informatik, M.Sc., FSPO 2014/Vertiefungsfach/Neuroinformatik • Medieninformatik, M.Sc., FSPO 2014/Kernfach/Praktische und Angewandte Informatik • Medieninformatik, M.Sc., FSPO 2014/Vertiefungsfach Medieninformatik/ Mustererkennung • Medieninformatik, M.Sc., FSPO 2014/Vertiefungsfach Medieninformatik/ Neuroinformatik • Software Engineering, M.Sc., FSPO 2014/Kernfach/Praktische und Angewandte Informatik • Informatik, M.Sc., FSPO 2017/Kernfach/Praktische und Angewandte Informatik • Informatik, M.Sc., FSPO 2017/Vertiefungsfach/Mustererkennung • Informatik, M.Sc., FSPO 2017/Vertiefungsfach/Neuroinformatik • Mathematics, M. Sc., FSPO 2024, compulsory elective modules in the subsidiary subject Computer Science • Mathematics, M. Sc., FSPO 2024, compulsory elective modules in the multidisciplinary subsidiary subject • Medieninformatik, M.Sc., FSPO 2017/Kernfach/Praktische und Angewandte Informatik • Medieninformatik, M.Sc., FSPO 2017/Vertiefungsfach Medieninformatik/ Mustererkennung • Medieninformatik, M.Sc., FSPO 2017/Vertiefungsfach Medieninformatik/ Neuroinformatik • Software Engineering, M.Sc., FSPO 2017/Kernfach/Praktische und Angewandte Informatik • Mathematics and Management, M. Sc., FSPO 2024, compulsory elective modules in Computer Science • Cognitive Systems, M.Sc., FSPO 2017/Special Subject/Learning & Memory

Recommended prerequisites	Linear algebra, analysis, probability theory. The required background knowledge is taught in the course "Foundations and Concepts of Cognitive Systems Modeling".
Learning objectives	Students acquire knowledge about different machine learning approaches (professional competence). In exercises, students are able to implement different learning concepts (methodological expertise). Students are able to make use of theoretical principles and transfer them to technical applications (transfer and evaluation competence).
Syllabus	The course provides a broad introduction to machine learning covering the following areas: • Concept learning • Learning in logic-based systems • Statistical learning • Unsupervised learning • Reinforcement learning • Bayesian learning • Kernel learning
Literature	• Mitchell "Machine Learning" • Bishop ”Pattern recognition and machine learning” • Russell & Norvig ”Artificial intelligence. A modern approach”
Teaching and learning methods	Learning Systems I (Vorlesung) (3 SWS), Learning Systems I (Übung) (1 SWS
Workload	Präsenzzeit: 60h Vor- und Nachbereitung: 120h Summe: 180h
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. If a specified academic work is achieved, a grade bonus is awarded at the immediately following examination. The examination grade is improved by one grade level, but not better than 1.0. An improvement from 5.0 to 4.0 is not possible. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	The course provides the foundation for Learning Systems II and other advanced machine learning courses.

Mathematical Statistics

Modules referring to Specialization

Code	8832872818
ECTS credits	9
Attendance time	6
Language of instruction	German / English
Duration	1
Cycle	each Winter Semester
Coordinator	Prof. Dr. Evgeny Spodarev
Instructor(s)	Lecturers of stochastics
Allocation of study programmes	Mathematics, B.Sc., FSPO 2018, compulsory elective modules in Apllied Mathematics Mathematics and Management, B.Sc., FSPO 2018, compulsory elective modules in Stochastics/Optimisation/Financial Mathematics Mathematical Biometry, B.Sc., FSPO 2018, compulsory elective modules in Stochastics Mathematics, M.Sc., FSPO 2018, compulsory elective modules in Apllied Mathematics Mathematics and Management, M.Sc., FSPO 2018, compulsory elective modules in Stochastics/Optimisation/Financial Mathematics Mathematical Biometry, M.Sc., FSPO 2018, compulsory elective modules in Mathematics and Statistics Finance, M.Sc., FSPO 2017, compulsory elective modules in Mathematics Computer Science, M.Sc., FSPO 2017, compulsory elective modules Applied Subject Mathematics - Advanced Mathematical Data Science, M.Sc., FSPO 2021, compulsory module
Recommended prerequisites	• Elementary Probability Theory and Statistics ("Elementare Wahrscheinlichkeitsrechnung und Statistik") • Probability Theory and Stochastic Processes ("Wahrscheinlichkeitstheorie und Stochastische Prozesse")
Learning objectives	Statistics deals with the question of how to obtain information about a larger totality from data sets (samples) using mathematical methods. The students • learn the basics of the theory of mathematical statistics comprehensively, understand and apply them

- are familiar with the most important estimation and testing methods,
- structure complex problems related to the analysis of data and select appropriate methods and techniques to solve them,
- acquire a broad basis for advanced statistical considerations, especially of a bio- and econometric nature,
- model data inference problems from application areas, develop solutions using statistical methods and interpret the results,
- recognise the possibilities and limitations of data analytical methods.

Syllabus

- Parametric model and basics of statistics
- Exponential family, completeness, sufficiency
- Techniques of point estimation
- Properties of estimators (MSE, bias, consistency, ...)
- Best unbiased estimator, Cramér-Rao inquality
- Confidence intervals
- Statistical hypothesis testing, connection between tests and confidence intervals
- Density estimation or introduction to linear models

Literature

- P. Bickel, K. Doksum, Mathematical Statistics: Basic Ideas and Selected Topics, Prentice Hall
- G. Casella, R.L. Berger, Statistical Inference, Duxbury
- Lehmann, E. L., Casella, G. (2006). Theory of point estimation. Springer.
- Lehmann, E. L., Romano, J. P. (2005). Testing statistical hypotheses. Springer.
- Rüschendorf, L (2014). Mathematische Statistik. Springer.

Teaching and learning methods

Mathematische Statistik (Lecture) (4 SWS),
Mathematische Statistik (Exercise) (2 SWS)

Workload

Classroom hours: 84 h
Individual study time: preparation and postprocessing: 64 h, Exercise 90 h, Revision and exam 32 h
Total: 270 h

Assessment

The module examination consists of a graded written examination. Participation in the examination requires an ungraded study achievement. The type, content and scope of the study achievement will be announced in good time in the course information and the course catalogue.

Grading procedure

The module grade is equal to the examination grade.

Basis for

Courses with further specialisation in stochastics, optimization, finance, actuarial and data science

Medical Wearables I

Modules referring to Specialization

Code	8832875335
ECTS credits	5
Attendance time	4
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Prof. Walter Karlen
Instructor(s)	Prof. Walter Karlen
Allocation of study programmes	<p>Master Communications and Computer Engineering <p>Master Electrical Engineering and Information Technology <p>Master Communication and Information Technology <p>Master Biophysics <p>Master Computational Science and Engineering <p>
Recommended prerequisites	None
Learning objectives	At the end of the course, students can • define medical wearables and put them into context of current medical technologies • understand the principles that guide medical wearables • can select from existing software and hardware technologies to design modern wearables for suitable applications • can analyse data retrieved from medical wearables • understand the business models behind medical wearables
Syllabus	This course is centered about the technology and the applications that drive modern medical wearables. Medical wearables play an increasingly important role in health care delivery, shifting the focus on the patient, enable continuous measurements. Wearables can take on different shapes and forms, from bracelets, mobile phones, shirts or even implants. In common is their sensing and networking capabilities, making them also the ***internet of medical things***. We extensively discuss requirements and technologies that solve common challenges in wearables due to miniaturisation, mobility, uncertainty and data load.

Applications of wearable point-of-care and mobile health devices will be presented and physiological background given.

The main **objectives** are to

- Understand the data path from sensor to clinical decision making
- Apply the most suitable technologies to solve design challenges for medical wearables

The course will be based on problem based, interactive learning.

The exercises will be based on concrete challenges with real wearables and their data.

Literature	Will be provided on moodle and during lectures
Teaching and learning methods	Lecture: 2SWS Exercise: 2SWS
Workload	Active: 90 Prep & eval: 60 Sum 150
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. If a specified academic work is achieved, a grade bonus is awarded in accordance with §17 (3a) of the General Examination Regulations at the immediately following examination. The examination grade is improved by one grade level, but not better than 1.0. An improvement from 5.0 to 4.0 is not possible. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	-

Molecular Motors

Modules referring to Specialization

Code	8832874003
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Prof. Dr. Christof Gebhardt
Allocation of study programmes	Physics M.Sc., elective module Biophysics M.Sc., elective module Wirtschaftsphysik M.Sc., elective module
Recommended prerequisites	Fundamentals in biophysics or soft matter physics
Learning objectives	Students who have successfully completed this module • understand complex experimental setups in modern biophysics. • can apply fundamental biophysical methods to current molecular and cell biological issues. • are able to describe biological phenomena using physical models of varying complexity.
Syllabus	• Cytoskeletal molecular motors • Stepping mechanisms • Coupling of mechanical and chemical cycles • Force production: Powerstroke vs. Brownian ratchet • Filament polymerization • Force production of cytoskeletal filaments • Length control of cytoskeletal filaments by molecular motors • Force-induced cooperation of molecular motors • DNA-based molecular motors • Models of gene regulation • Molecular motors and hearing

Literature	• Phillips, Kondev, Theriot: Physical Biology of the Cell, Garland Science • Howard: Mechanism of Motor Proteins and the Cytoskeleton, Sinaur and Associates • Lakowicsz: Principles of Fluorescence Spectroscopy, Springer US
Teaching and learning methods	Lecture (2 hours per week)
Workload	30 hours lecture (attendance time) 60 hours self-study and exam preparation Total: 90 hours
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants.
Grading procedure	The module grade is equal to the examination grade.
Basis for	Research in the field of biophysics

Neurobiology and Behaviour

Modules referring to Specialization

Code	8832878011
ECTS credits	15
Attendance time	13
Language of instruction	English
Duration	1
Cycle	each Summer Semester
Coordinator	Prof. Dr. Annika Herwig
Instructor(s)	Prof. Dr. Annika Herwig, Dr. Wolfgang Mader, Dr. Victoria Diedrich
Allocation of study programmes	• Biology, M.Sc., FSPO 2022/Compulsory elective area/Research focus Biology • Biology teaching degree, B.Sc.,, M.Ed., FSPO 2022/Compulsory elective area/ Biology
Recommended prerequisites	Good knowledge of neurobiology and behavioral biology, e.g., from animal physiology in th bachelor's degree.
Learning objectives	Students who have successfully completed this module have • an in-depth understanding of biological rhythms, energy balance and thermoregulation as well as their neurobiological regulatory mechanisms. • have experimental experience with neuroanatomical methods to characterize neurons and glial cells in the mammalian brain and in-depth knowledge of the anatomy and function of the hypothalamus. • have the competencies and skills to carry out experiments, process and present data, including statistical methods, largely independently, in structured presentations or posters.
Syllabus	Lecture • temporal organization of physiological processes and repeated patterns of behavior of organisms • neuronal and molecular control of circadian and seasonal rhythms • thermoregulation and metabolism • neuronal control of energy balance and thermoregulation • principles for scientific work with mammals

	Practical and seminar • experimental and theoretical processing of the above topics using selected examples • standard behavioral tests and metabolic rate measurements in small rodents • data analytics anatomical processing of relevant structures in the hypothalamus and thalamus fluorescence microscopy and image analysis
Literature	• Refinetti: Circadian Physiology, Routlege Taylor & Francis Group • Specific literature on the practical experiments and seminar topics
Teaching and learning methods	• Neurobiology and Behaviour (Seminar) (2 classroom hours per week, 3 ECTS, no.: 18911), • Neurobiology and Behaviour (Advanced practical course) (9 classroom hours per week, 9 ECTS, no.: 18511), • Neurobiology and Behaviour (Lecture) (2 classroom hours per week, 3 ECTS, no.: 18011)
Workload	Attendance: 195 h Private study: 255 h Sum: 450 h
Assessment	The module examination consists of a graded written examination, the graded performance in the advanced practical course including the poster presentation and an ungraded participation in the seminar. The evaluation scheme will be announced at the beginning of the module.
Grading procedure	The module grade is equal to the percentage-weighted average of the individual grades with the following weights: written examination (70 %), advanced practical course (30%).
Basis for	Master's thesis in our group.

Physics of Medical Imaging

Modules referring to Specialization

Code	8832877107
ECTS credits	6
Attendance time	5
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Prof. Volker Rasche, Dr. Tobias Speidel, Prof. Gerhard Glatting
Allocation of study programmes	i.e. Physics M.Sc., D - Examination Field Master Programmes, E - Examination Field General Range of Studies, 1st or 2nd semester
Recommended prerequisites	Undergraduate courses in atomic physics and quantum mechanics
Learning objectives	Students who successfully passed this module: • understand the basic concepts of common medical imaging modalities • have a deeper understanding of nuclear magnetic resonance • have a basic understanding of atomic interactions • have a basic understanding of image reconstruction techniques • have practical knowledge in acquiring spectroscopic and MRI data
Syllabus	• Principles of nuclear magnetic resonance • NMR spectroscopy • Basics of MR imaging • Fourier space: Encoding, acquisition and reconstruction • X-Ray imaging & Computed tomography: Physical principle and contrast generation • Nuclear Imaging (PET and SPECT): Physical principles and contrast generation • Ultrasound: Basic principles and contrast generation • General application of medical imaging methods including hands-on sessions
Literature	• Maier, Andreas, et al., *Medical imaging systems: An introductory guide*.

- Slichter, Charles P. *Principles of magnetic resonance*.
- Levitt, Malcolm H. *Spin dynamics: basics of nuclear magnetic resonance.*

Teaching and learning methods	Lecture (4 hours per week) with additional hands-on-sessions and seminar
Workload	60 hours lecture (attendance time) 30 hours hands-on-sessions & seminar (attendance time) 90 hours private study Total: 180 hours
Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. Participation in the examination requires an ungraded study achievement. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	-

Protein Biochemistry

Modules referring to Specialization

Code	8832878008
ECTS credits	15
Attendance time	13
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Prof. Dr. Marcus Fändrich
Instructor(s)	Prof. Dr. Marcus Fändrich, Dr. Christian Haupt
Allocation of study programmes	• Biochemistry, M.Sc., FSPO 2022/Compulsory elective area/Specialization I: Biochemistry • Biochemistry, M.Sc., FSPO 2022/Compulsory elective area/Specialization III: Biology, Biochemistry, Chemistry & Biophysics
Recommended prerequisites	Content-related: The content of the following courses of the Bachelor Biochemistry: Lecture and seminar Biochemistry I, practical biochemical exercises I to IV (especially the practical exercises of the Institute of Protein Biochemistry), Cell Biology. Formal: None
Learning objectives	Students who have successfully completed this module, • possess in-depth knowledge of the structural composition of proteins as well as their modification, stability, folding, misfolding and biotechnological use, • have basic knowledge in the field of protein folding diseases and pharmaceutical proteins, • have experience in carrying out protein biochemical laboratory analyses, • have experience in giving seminar presentations, • are familiar with basic scientific skills such as the critical evaluation of data quality and the scientific presentation of research results.

Syllabus	The lecture deals with important topics of protein biochemistry and typically covers aspects such as amino acids, protein modification, random coil and helical structure, b-sheet structures, protein stability and solubility, protein folding in vitro, protein misfolding and fibrillation, amyloid and prion diseases, protein engineering, protein expression, antibody biotechnology, pharmaceutical proteins, cellular folding assistants. The seminar consists of presentations by the students and their teachers. Depending on the number of students enrolled in the module, the seminar may cover topics on protein misfolding diseases (e.g. Alzheimer's, Parkinson's, Creutzfeldt-Jakob and other „prion" diseases, systemic amyloidosis) or pharmaceutical proteins for the treatment of human diseases (e.g. diabetes, hemophilia, macula degeneration, thrombosis, cervix carcinoma or allergic asthma). The practical course provides hands-on-experience on, for example, the recombinant expression of proteins, the purification of proteins with column chromatography, protein quantification with different spectroscopic methods, protein gel electrophoresis and protein stability measurements with chemical denaturation. In addition, you will learn to critically evalaute and appropriately report scientific results.
Literature	Will be announced if necessary.
Teaching and learning methods	• Protein Biochemistry (Seminar) (2 classroom hours per week, 3 ECTS, no.: 18508), • Protein Biochemistry (Advanced practical course) (9 classroom hours per week, 9 ECTS, no.: 18908), • Protein Biochemistry and Structure Elucidation (Lecture) (2 classroom hours per week, 3 ECTS, no.: 15413)
Workload	Attendance: 195 h Private study: 255 h Sum: 450 h
Assessment	The module examination consists of a graded written examination, of completing an assignement on a given topic including the graded oral presentation of the results in the seminar and the graded performance in the advanced practical course including the protocol.
Grading procedure	The module grade is equal to the percentage-weighted average of the individual grades with the following weights: written examination (50 %), Seminar (40%), Advanced Practical Course (20%).
Basis for	Master thesis on protein biochemistry

Theoritical Modelling and Simulation

Modules referring to Specialization

Code	8832870337
ECTS credits	4
Attendance time	3
Language of instruction	German
Duration	1
Cycle	each Summer Semester
Coordinator	The Dean of Studies of Chemistry
Instructor(s)	Prof. Dr. Axel Groß
Allocation of study programmes	Bachelor Chemistry, compulsory area A1 Bachelor Chemistry and Management, elective area B2 Master Teaching Chemistry, elective module Mathematics, B. Sc., FSPO 2024, compulsory elective modules in the subsidiary subject Chemistry Mathematics, B. Sc., FSPO 2024, compulsory elective modules in the multidisciplinary subsidiary subject Mathematics, M. Sc., FSPO 2024, compulsory elective modules in the subsidiary subject Chemistry Mathematics, M .Sc., FSPO 2024, compulsory elective modules in the multidisciplinary subsidiary subject
Recommended prerequisites	Basic knowledge in mathematics and in physical chemistry
Learning objectives	Students who have successfully completed this module - have knowledge of methods for theoretical modeling and simulation ofchemically relevant systems - have the skill to handle simple simulation programs
Syllabus	In this module the following professional contents are taught:

	- Molecular modeling: description of the structure, reactivity, dynamics and kinetics of molecular systems using empirical and semi-empirical models - Introduction to theoretical foundations: Schrödinger equation, elementary principles of many-body theory, classical and quantum mechanical equations of motion, description of interatomic and intermolecular interactions - Electronic structure methods: Elementary representation of the basic algorithms and methods for the determination of the electronic structure, basis sets, calculation of the properties of smaller molecules with programs like e.g. gaussian - Further Methods for Structure Determination: Semiclassical Methods, Force Fields Molecular Dynamics Simulations - Execution and evaluation of simulations, reaction dynamics, determination of theorodynamic quantities - Kinetics and Thermodynamics of Chemical Processes: Methods for kinetic and thermodynamic simulation of chemical systems, statistical methods, Monte Carlo methods - Other computer applications in the natural sciences: Graphical representation of molecules and of the results of calculations and simulations
Literature	It is announced in the lecture
Teaching and learning methods	Lecture and practical exercises (2+1 hours per week)
Workload	Presence: 45 H Self Study: 75 H Total: 120 H
Assessment	The module examination consists of a graded written exam. Participation in the examination requires an ungraded academic work. Form, content and scope of the academic work will be announced at the beginning of the lecture and in the course catalogue.
Grading procedure	The module grade is equal to the examination grade.
Basis for	-

Additive Key Qualifications I

Modules referring to Interdisciplinary Competencies and Language Skills

Code	8832886100
ECTS credits	*keine Angaben*
Attendance time	*keine Angaben*
Language of instruction	*not specified*
Duration	1
Cycle	each Semester
Coordinator	*not specified*
Instructor(s)	*not specified*
Allocation of study programmes	*not specified*
Recommended prerequisites	*not specified*
Learning objectives	*not specified*
Syllabus	*not specified*
Literature	*not specified*
Teaching and learning methods	*not specified*
Workload	*not specified*
Assessment	*not specified*
Grading procedure	*not specified*
Basis for	*not specified*

Additive Key Qualifications II

Modules referring to Interdisciplinary Competencies and Language Skills

Code	8832886200
ECTS credits	*keine Angaben*
Attendance time	*keine Angaben*
Language of instruction	*not specified*
Duration	2
Cycle	each Winter Semester
Coordinator	*not specified*
Instructor(s)	*not specified*
Allocation of study programmes	*not specified*
Recommended prerequisites	*not specified*
Learning objectives	*not specified*
Syllabus	*not specified*
Literature	*not specified*
Teaching and learning methods	*not specified*
Workload	*not specified*
Assessment	*not specified*
Grading procedure	*not specified*
Basis for	*not specified*

Additive Key Qualifications III

Modules referring to Interdisciplinary Competencies and Language Skills

Code	8832886300
ECTS credits	*keine Angaben*
Attendance time	*keine Angaben*
Language of instruction	English and German
Duration	2
Cycle	each Winter Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Lecturers at the Humboldt and Language Center of Ulm University
Allocation of study programmes	Quantum Engineering M.Sc., elective module
Recommended prerequisites	-
Learning objectives	students who have successfully completed this module • can apply intercultural and foreign language skills as well as/or knowledge and skills in the areas of teamwork, communication and presentation. • are able to reflect, test and evaluate the acquired key competencies as well as transfer and implement them in an argumentative way
Syllabus	Depending on the course
Literature	Depending on the course
Teaching and learning methods	e.g. 2 classroom hours
Workload	attendance: 30 h self-study: 60 h total: 90 h

Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	-

Additive Key Qualifications IV

Modules referring to Interdisciplinary Competencies and Language Skills

Code	8832886400
ECTS credits	*keine Angaben*
Attendance time	*keine Angaben*
Language of instruction	English or German
Duration	2
Cycle	each Winter Semester
Coordinator	Dean of Physics Studies
Instructor(s)	Lecturers at the Humboldt and Language Center of Ulm University
Allocation of study programmes	Quantum Engineering M.Sc., elective module
Recommended prerequisites	-
Learning objectives	students who have successfully completed this module • can apply intercultural and foreign language skills as well as/or knowledge and skills in the areas of teamwork, communication and presentation. • are able to reflect, test and evaluate the acquired key competencies as well as transfer and implement them in an argumentative way.
Syllabus	Depending on the course
Literature	Depending on the course
Teaching and learning methods	e.g. 2 classroom hours
Workload	attendance: 30 h self-study: 60 h total: 90 h

Assessment	The module examination consists of a graded written or oral examination, depending on the number of participants. The examination form will be announced in good time before the examination is held - at least 4 weeks before the examination date.
Grading procedure	The module grade is equal to the examination grade.
Basis for	-

Biology in Ulm: Stress response & resilience of biological systems

Modules referring to Complementary Area

Code	8832876603
ECTS credits	3
Attendance time	2
Language of instruction	English
Duration	1
Cycle	each Winter Semester
Coordinator	Dean of Studies Biology (Prof. Dr. Marcus Fändrich)
Instructor(s)	No English version available yet.
Allocation of study programmes	Biology, M.Sc., FSPO 2022/Compulsory area
Recommended prerequisites	No English version available yet.
Learning objectives	No English version available yet.
Syllabus	No English version available yet.
Literature	No English version available yet.
Teaching and learning methods	Lecture Series Stress Response & Resilience (Lecture) (2 classroom hours per week, 3 ECTS, no.: 18515)
Workload	Attendance: 30 h Private study: 60 h Sum: 90 h
Assessment	The module examination consists of an ungraded written examination.

Grading procedure	The module is not graded.
Basis for	No English version available yet.

Patent Law

Modules referring to Complementary Area

Code	8832870555
ECTS credits	3
Attendance time	1
Language of instruction	German
Duration	1
Cycle	*keine Angaben*
Coordinator	Dean of studies (chemistry department)
Instructor(s)	Dr. Helmut Reitzle, Dr. Rainer Kränzle
Allocation of study programmes	Master Chemistry, elective area B2 Master Chemistry and Management, elective area B3 Further degree programs which have assigned this module to their curriculum
Recommended prerequisites	Formally: Refer to the subject-specific examination regulations of the respective study course, in the version effective when taking up the study program. Contentually: None.
Learning objectives	Students who have successfully completed this module • have knowledge about the fundamentals of the patent system.
Syllabus	This module covers the following subject-specific topics: • Part 1: Rights of use, exhaustion of rights of use using powers, mediate patent infringement, right of prior use, restriction of the effect of the patent, extend of protection, infringement of the protective right, the rights to the invention. • Part 2: Novelty, the inventive step, industrial application. • Part 3: procedural law, general rules, representation, patent application, procedure up to granting, eliminations of patents, objection, nullity.
Literature	Literature will be provided in the lecture

Teaching and learning methods	Lecture (1 hour per week)
Workload	Attendance: 15 h Private study: 75 h Sum: 90 h
Assessment	The module examination consists of the ungraded participation in all phases of the course.
Grading procedure	The module is not graded
Basis for	-