Module Descriptions

Master of Science Biophysics

Examination Regulations in the Version of: 2024
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Interdisciplinary Competencies and Language Skills

Additive Key Qualifications I
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Complementary Area

Biology in Ulm: Stress response & resilience of biological systems
Patent Law
# Advanced Biophysics Seminar

**Modules referring to Compulsory Area**

<table>
<thead>
<tr>
<th>Code</th>
<th>8832875597</th>
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<tr>
<td>ECTS credits</td>
<td>3</td>
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<tr>
<td>Attendance time</td>
<td>2</td>
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<td>Language of instruction</td>
<td>English</td>
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<tr>
<td>Duration</td>
<td>1</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Jens Michaelis</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Christof Gebhardt, Prof. Kay Gottschalk, Prof. Jens Michaelis</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>Biophysics M.Sc., compulsory module, 1st or 2nd semester</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>Basic knowledge of physics, biology and biochemistry</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>No English version available yet.</td>
</tr>
<tr>
<td>Syllabus</td>
<td>Preparation and presentation of a scientific lecture on a topic from biophysics or soft matter physics.</td>
</tr>
<tr>
<td>Literature</td>
<td>No English version available yet.</td>
</tr>
<tr>
<td>Teaching and learning methods</td>
<td>Seminar (2 hours per week)</td>
</tr>
<tr>
<td>Workload</td>
<td>30 hours seminar (attendance)</td>
</tr>
<tr>
<td></td>
<td>60 hours talk preparation</td>
</tr>
<tr>
<td></td>
<td>Total: 90 hours</td>
</tr>
</tbody>
</table>
Assessment
The module examination consists of completing an assignment on a given topic and a 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 Institute 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
<table>
<thead>
<tr>
<th>Teaching and learning methods</th>
<th>Research project to be carried out in the Institute of Biophysics or the Institute for Experimental Physics at Ulm University.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workload</td>
<td>450 hours</td>
</tr>
<tr>
<td></td>
<td>e.g. 11 weeks full-time</td>
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<tr>
<td>Assessment</td>
<td>The grade of the module will be the grade of the written exam. No prerequisites are necessary for exam registration.</td>
</tr>
<tr>
<td>Grading procedure</td>
<td>The grade of the module will be the grade of the exam.</td>
</tr>
<tr>
<td>Basis for</td>
<td>Master's thesis</td>
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### Biophysics Lab - A

Modules referring to Compulsory Area

<table>
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<tr>
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<tr>
<td>ECTS credits</td>
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<td>8</td>
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<tr>
<td>Language of instruction</td>
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<tr>
<td>Duration</td>
<td>1</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>No English version available yet.</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>No English version available yet.</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>No English version available yet.</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>No English version available yet.</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>No English version available yet.</td>
</tr>
<tr>
<td>Syllabus</td>
<td>No English version available yet.</td>
</tr>
<tr>
<td>Literature</td>
<td>No English version available yet.</td>
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<tr>
<td>Teaching and learning methods</td>
<td>No English version available yet.</td>
</tr>
<tr>
<td>Workload</td>
<td>No English version available yet.</td>
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#### 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.
<table>
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<tr>
<td>Duration</td>
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<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
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<tr>
<td>Coordinator</td>
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<td>Instructor(s)</td>
<td>No English version available yet.</td>
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<td>Allocation of study programmes</td>
<td>No English version available yet.</td>
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<tr>
<td>Recommended prerequisites</td>
<td>No English version available yet.</td>
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<tr>
<td>Learning objectives</td>
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<td>Literature</td>
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<tr>
<td>Workload</td>
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<tr>
<td>Assessment</td>
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</tr>
<tr>
<td>Grading procedure</td>
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Basis for

No English version available yet.
Biophysics Lecture Series
Modules referring to Compulsory Area

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<td>Language of instruction</td>
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<td>Duration</td>
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<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
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<tr>
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<tr>
<td>Allocation of study programmes</td>
<td>Master Biophysics, 1st semester</td>
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<tr>
<td>Recommended prerequisites</td>
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<tr>
<td>Learning objectives</td>
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<td>Literature</td>
<td>No English version available yet.</td>
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<tr>
<td>Teaching and learning methods</td>
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<tr>
<td>Workload</td>
<td>No English version available yet.</td>
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<tr>
<td>Assessment</td>
<td>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.</td>
</tr>
<tr>
<td><strong>Grading procedure</strong></td>
<td>The module grade is equal to the examination grade.</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td><strong>Basis for</strong></td>
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**Master's Thesis**  
**Modules referring to Compulsory Area**

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<td>Attendance time</td>
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<td>Language of instruction</td>
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<tr>
<td>Duration</td>
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</tr>
<tr>
<td>Cycle</td>
<td>each Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>not specified</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>not specified</td>
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<tr>
<td>Allocation of study programmes</td>
<td>not specified</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>not specified</td>
</tr>
<tr>
<td>Learning objectives</td>
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<tr>
<td>Syllabus</td>
<td>not specified</td>
</tr>
<tr>
<td>Literature</td>
<td>not specified</td>
</tr>
<tr>
<td>Teaching and learning methods</td>
<td>not specified</td>
</tr>
<tr>
<td>Workload</td>
<td>not specified</td>
</tr>
<tr>
<td>Assessment</td>
<td>not specified</td>
</tr>
<tr>
<td>Grading procedure</td>
<td>not specified</td>
</tr>
<tr>
<td>Basis for</td>
<td>not specified</td>
</tr>
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</table>
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
- Berg: Random Walks in Biology, Princeton University Press
• Alberts: Molecular Biology of the Cell, Garland Science

<table>
<thead>
<tr>
<th>Teaching and Learning methods</th>
<th>Biophysics (lecture/seminar) (4 classroom hours per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laboratory (1 classroom hour per week)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Workload</th>
<th>Attendance: 90 h</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Private study: 90 h</td>
</tr>
<tr>
<td></td>
<td>Total: 180 h</td>
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</table>

| 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

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<tr>
<th>Code</th>
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<tbody>
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<td>2</td>
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<tr>
<td>Language of instruction</td>
<td>English</td>
</tr>
<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>The Dean of Studies of Chemistry</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Dr. D. Bresser</td>
</tr>
</tbody>
</table>

**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

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

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<thead>
<tr>
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<td>Attendance time</td>
<td>4</td>
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<td>Language of instruction</td>
<td>English</td>
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<tr>
<td>Duration</td>
<td>1</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Dean of Physics Studies</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Dr. Ressa Said, Dr. Genko Genov</td>
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<tr>
<td>Allocation of study programmes</td>
<td>Quantum Engineering M.Sc., Biophysics M.Sc., adaptation module, 1st semester</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>None</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>Students who successfully passed this module</td>
</tr>
<tr>
<td></td>
<td>• have an overview on essential mathematical methods for the solution of generic problems in Physics.</td>
</tr>
<tr>
<td></td>
<td>• have trained to analyze and solve physical problems quantitatively.</td>
</tr>
<tr>
<td>Syllabus</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>• Application of complex numbers and variables</td>
</tr>
<tr>
<td></td>
<td>• Fundamentals of matrices and its applications</td>
</tr>
<tr>
<td></td>
<td>• Further differentials and integrals, differential equations</td>
</tr>
<tr>
<td></td>
<td>• Fourier Series and Transform, Laplace Transform</td>
</tr>
<tr>
<td></td>
<td>• Finite Difference and Spectral Solutions</td>
</tr>
<tr>
<td></td>
<td>• Calculus of Variations</td>
</tr>
</tbody>
</table>
### 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 hour 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, 1\textsuperscript{st} 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 | -
<table>
<thead>
<tr>
<th><strong>Teaching and learning methods</strong></th>
<th>Lab work with 4 full-day experiments including introductory and final discussions.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workload</strong></td>
<td>45 hours laboratory course (attendance time)</td>
</tr>
<tr>
<td></td>
<td>75 hours self-study, data analysis, report writing</td>
</tr>
<tr>
<td></td>
<td>Total: 120 hours</td>
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<tr>
<td><strong>Assessment</strong></td>
<td>The grade of the module will be the grade of the oral exam. No prerequisites are necessary for exam registration.</td>
</tr>
<tr>
<td><strong>Grading procedure</strong></td>
<td>The grade of the module will be the grade of the exam.</td>
</tr>
<tr>
<td><strong>Basis for</strong></td>
<td>All other modules</td>
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</table>
# Soft Matter Physics and Biophysics

**Modules referring to Adaptation**

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<td><strong>Language of instruction</strong></td>
<td>English</td>
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<tr>
<td><strong>Duration</strong></td>
<td>1</td>
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<tr>
<td><strong>Cycle</strong></td>
<td>each Summer Semester</td>
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<tr>
<td><strong>Coordinator</strong></td>
<td>Dean of Physics Studies</td>
</tr>
<tr>
<td><strong>Instructor(s)</strong></td>
<td>Prof. Dr. Christof Gehardt, Prof. Kay E. Gottschalk, Prof. Dr. Jens Michaelis</td>
</tr>
</tbody>
</table>

## 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 microscopy, force spectroscopy and microscopy
- Experimental techniques in molecular biology: cloning and protein purification
Literature


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
<table>
<thead>
<tr>
<th><strong>Literature</strong></th>
<th></th>
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<table>
<thead>
<tr>
<th><strong>Teaching and learning methods</strong></th>
<th>Lecture (2 hours/week)</th>
</tr>
</thead>
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<table>
<thead>
<tr>
<th><strong>Workload</strong></th>
<th>30 hours: attendance time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60 hours: self study and exam preparation</td>
</tr>
<tr>
<td></td>
<td>total: 90 hours</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Assessment</strong></th>
<th>The module examination consists of a graded written or oral examination, depending on the number of participants.</th>
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<table>
<thead>
<tr>
<th><strong>Grading procedure</strong></th>
<th>The module grade is equal to the examination grade.</th>
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</table>

<table>
<thead>
<tr>
<th><strong>Basis for</strong></th>
<th>Research in the field of biophysics</th>
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Gene Expression
Modules referring to Biophysics Electives

<table>
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<th>Code</th>
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<td>ECTS credits</td>
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<tr>
<td>Attendance time</td>
<td>2</td>
</tr>
<tr>
<td>Language of instruction</td>
<td>English</td>
</tr>
<tr>
<td>Duration</td>
<td>1</td>
</tr>
<tr>
<td>Cycle</td>
<td>one-time</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. Jens Michaelis</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. Jens Michaelis</td>
</tr>
</tbody>
</table>

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
- Latchman: Gene control, Garöland Science 2010
- Armstrong: Epigenetics, Garland Science 2014
- Buc and Strick: RNA Polymerases as Molecular Motors, RSC Publishing 2009
- 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

### 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**

<table>
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<td>Duration</td>
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<tr>
<td>Cycle</td>
<td>each Semester</td>
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<tr>
<td>Coordinator</td>
<td>Dean of Physics Studies</td>
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<tr>
<td>Instructor(s)</td>
<td>All lecturers of the faculty of natural sciences.</td>
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<tr>
<td>Allocation of study programmes</td>
<td>Biophysics M.Sc. FSPO 2024, 3rd semester.</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>-</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>The internship serves to gain subject-related knowledge and experience in current research.</td>
</tr>
<tr>
<td>Syllabus</td>
<td>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.</td>
</tr>
<tr>
<td>Literature</td>
<td>tba</td>
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<tr>
<td>Teaching and learning methods</td>
<td>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.</td>
</tr>
<tr>
<td>Workload</td>
<td>450 h</td>
</tr>
<tr>
<td></td>
<td>e.g. 11 weeks full-time</td>
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<tr>
<td><strong>Assessment</strong></td>
<td>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.</td>
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<tr>
<td><strong>Grading procedure</strong></td>
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<tr>
<td><strong>Basis for</strong></td>
<td>Master's thesis</td>
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</table>
# 3D Deep Learning

Modules referring to Specialization

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<td>Language of instruction</td>
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<tr>
<td>Duration</td>
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<tr>
<td>Cycle</td>
<td>irregular</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. Timo Ropinski</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. Timo Ropinski</td>
</tr>
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## 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/Viertelungsbereich Informatik/Praktische Informatik
- Künstliche Intelligenz, M.Sc., FSPO 2021/Viertelungsfach Künstliche Intelligenz/Perzeption, Interaktion und Aktion
- Künstliche Intelligenz, M.Sc., FSPO 2022/Viertelungsbereich 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/Viertelungsbereich Medieninformatik/ Medieninformatik
- Medieninformatik, M.Sc., FSPO 2022/Viertelungsbereich 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/Viertelungsbereich Software Engineering/Praktische Informatik
- Mathematics and Management, M.Sc., FSPO 2024, compulsory elective modules in Computer Science
<table>
<thead>
<tr>
<th><strong>Recommended prerequisites</strong></th>
<th>We assume previous knowledge in computer science, but not necessarily in machine learning.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning objectives</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Syllabus</strong></td>
<td>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 developing, 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.</td>
</tr>
<tr>
<td><strong>Literature</strong></td>
<td>• Ian Goodfellow and Yoshua Bengio and Aaron Courville: Deep Learning, MIT Press 2016.</td>
</tr>
<tr>
<td><strong>Teaching and learning methods</strong></td>
<td>3D Deep Learning (Übung) (2 SWS), 3D Deep Learning (Vorlesung) (2 SWS)</td>
</tr>
</tbody>
</table>
| **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 work individually 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, 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 β-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


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**

Syllabus Seminar Scientific Integrity, Data Analysis & Management:
- using R and R studio
- data management
- linear models
- 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**

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

Seminar Philosophy of Science:

**Teaching and learning methods**

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
<table>
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<tr>
<th><strong>Inorganic Materials Synthesis/Inorganic Nanomaterials</strong></th>
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<tbody>
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<td><strong>Modules referring to Specialization</strong></td>
<td></td>
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<tr>
<td><strong>Code</strong></td>
<td>8832871300</td>
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<tr>
<td><strong>ECTS credits</strong></td>
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<tr>
<td><strong>Attendance time</strong></td>
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<td><strong>Language of instruction</strong></td>
<td>English</td>
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<tr>
<td><strong>Duration</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Cycle</strong></td>
<td>each Summer Semester</td>
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</table>
| **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, elective area 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 |
<table>
<thead>
<tr>
<th><strong>Teaching and learning methods</strong></th>
<th>Seminar (2 hours per week)</th>
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</thead>
<tbody>
<tr>
<td><strong>Workload</strong></td>
<td>Presence: 30 h</td>
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<td></td>
<td>Private study: 60 h</td>
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<td><strong>Assessment</strong></td>
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<td><strong>Grading procedure</strong></td>
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<tr>
<td><strong>Basis for</strong></td>
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### Appropriate Medical Device Design

Modules referring to Specialization

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<td>Language of instruction</td>
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<td>Duration</td>
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</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Walter Karlen</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Walter Karlen</td>
</tr>
</tbody>
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**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


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 Bachelor's Degree Program in Biophysics.
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.

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<thead>
<tr>
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<td>Basis for</td>
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</table>
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 analysis, signal transduction, pathway analysis, modeling- and reconstruction techniques


<table>
<thead>
<tr>
<th>Teaching and learning methods</th>
<th>Seminar, exercises</th>
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<tr>
<td><strong>Workload</strong></td>
<td>~ 160 h (54h presence, ~108h self studies)</td>
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<td><strong>Assessment</strong></td>
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<td><strong>Basis for</strong></td>
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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
<table>
<thead>
<tr>
<th><strong>Literature</strong></th>
<th>Literature will be announced in the lecture.</th>
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<tr>
<td><strong>Teaching and learning methods</strong></td>
<td>Seminar (2 hours per week)</td>
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</table>
| **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

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<th>Workload</th>
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<td>45 hours laboratory course (attendance time)</td>
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<td>90 hours self-study and exam preparation</td>
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<th>Research in the field of Biophysics</th>
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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
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<th>it is announced in the lecture</th>
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<td>The lecture is currently offered as a combined version of Biopolymers and Introduction to Natural Products Chemistry.</td>
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<td></td>
<td>Private study: 60 h</td>
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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 2021, Specialization: Actuarial Science, 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

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
- 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

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<td><strong>Coordinator</strong></td>
<td>Dean of Physics Studies</td>
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<tr>
<td><strong>Instructor(s)</strong></td>
<td>Prof. Kay Gottschalk</td>
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**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  
| **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 |

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Date printed: 05. August 2024
### Econophysics: Numerical Simulations

**Modules referring to Specialization**

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<td>Dean of Physics Studies</td>
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<tr>
<td>Instructor(s)</td>
<td>Dr. Jürgen Stockburger</td>
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</tbody>
</table>

**Allocation of study programmes**
- Physics M.Sc., elective module, 1st or 2nd semester
- Wirtschaftsphysik M.Sc., elective module, 1st - 3rd 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**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Lecture</td>
<td>(3 hours per week)</td>
</tr>
<tr>
<td>Exercise</td>
<td>(2 hours per week)</td>
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</tbody>
</table>

**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

• 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

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<td>Prof. Dr. Jens Michaelis</td>
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**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**
- 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
- Latchman: Gene control, Garőland Science 2010
- Armstrong: Epigenetics, Garland Science 2014
- Buc and Strick: RNA Polymerases as Molecular Motors, RSC Publishing 2009
- 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

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<td>Dr. Raiker Witter</td>
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</table>

### Allocation of study programmes
- Physics M.Sc., D - Examination Field Master Programmes, E - Examination Field General Range of Studies, 1\textsuperscript{st} or 2\textsuperscript{nd} 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.;

(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 (ESR), 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
- 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**

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<td>The Dean of Studies of Chemistry</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. Thorsten Bernhardt</td>
</tr>
</tbody>
</table>

## 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 number 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**

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<tr>
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<td>Prof. Dr. Dr. Daniel Braun</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. Dr. Daniel Braun</td>
</tr>
</tbody>
</table>

**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".

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**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)

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**Workload**

- Präsenzzeit: 60h
- Vor- und Nachbereitung: 120h
- Summe: 180h

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**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.

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**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

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<td>Prof. Dr. Evgeny Spodarev</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Lecturers of stochastics</td>
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### Allocation of study programmes

- Mathematics, B.Sc., FSPO 2018, compulsory elective modules in Applied 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 Applied 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 inequality
• 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

**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

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<td>Prof. Walter Karlen</td>
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<td>Prof. Walter Karlen</td>
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**Allocation of study programmes**
- Master Communications and Computer Engineering
- Master Electrical Engineering and Information Technology
- Master Communication and Information Technology
- Master Biophysics
- Master Computational Science and Engineering

**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.

<table>
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<tr>
<th>Literature</th>
<th>Will be provided on moodle and during lectures</th>
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</table>
| 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

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 the 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

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<tr>
<td>Coordinator</td>
<td>Dean of Physics Studies</td>
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<tr>
<td>Instructor(s)</td>
<td>Prof. Volker Rasche, Dr. Tobias Speidel, Prof. Gerhard Glatting</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>i.e. Physics M.Sc., D - Examination Field Master Programmes, E - Examination Field General Range of Studies, 1\textsuperscript{st} or 2\textsuperscript{nd} semester</td>
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<tr>
<td>Recommended prerequisites</td>
<td>Undergraduate courses in atomic physics and quantum mechanics</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>Students who successfully passed this module:</td>
</tr>
<tr>
<td></td>
<td>• understand the basic concepts of common medical imaging modalities</td>
</tr>
<tr>
<td></td>
<td>• have a deeper understanding of nuclear magnetic resonance</td>
</tr>
<tr>
<td></td>
<td>• have a basic understanding of atomic interactions</td>
</tr>
<tr>
<td></td>
<td>• have a basic understanding of image reconstruction techniques</td>
</tr>
<tr>
<td></td>
<td>• have practical knowledge in acquiring spectroscopic and MRI data</td>
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</table>

## 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, β-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 evaluate 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 assignment 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
Theoretical 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 of chemically 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

<table>
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<tbody>
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<thead>
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<td>Lecture and practical exercises (2+1 hours per week)</td>
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<th>Workload</th>
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<tr>
<td>Presence: 45 H</td>
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<td>Self Study: 75 H</td>
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### Additive Key Qualifications I

**Modules referring to Interdisciplinary Competencies and Language Skills**

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<td>Teaching and learning methods</td>
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<tr>
<td>Workload</td>
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<td>Assessment</td>
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<td>Grading procedure</td>
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Master of Science Biophysics  
Date printed: 05. August 2024  
page 83 of 92
# Additive Key Qualifications II

Modules referring to Interdisciplinary Competencies and Language Skills

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<td>ECTS credits</td>
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<td>Attendance time</td>
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<td>Cycle</td>
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<td>Instructor(s)</td>
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<tr>
<td>Allocation of study programmes</td>
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<td>Recommended prerequisites</td>
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<tr>
<td>Learning objectives</td>
<td>not specified</td>
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<tr>
<td>Syllabus</td>
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### Additive Key Qualifications III

Modules referring to Interdisciplinary Competencies and Language Skills

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<td>Attendance time</td>
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<tr>
<td>Language of instruction</td>
<td>English and German</td>
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<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
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<tr>
<td>Coordinator</td>
<td>Dean of Physics Studies</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Lecturers at the Humboldt and Language Center of Ulm University</td>
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<tr>
<td>Allocation of study programmes</td>
<td>Quantum Engineering M.Sc., elective module</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
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</table>
| 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

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<tr>
<td>Language of instruction</td>
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<td>Duration</td>
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<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
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<tr>
<td>Coordinator</td>
<td>Dean of Physics Studies</td>
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<tr>
<td>Instructor(s)</td>
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</tr>
<tr>
<td>Learning objectives</td>
<td>students who have successfully completed this module</td>
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<td></td>
<td>• can apply intercultural and foreign language skills as well as/or knowledge and skills in the areas of teamwork, communication and presentation.</td>
</tr>
<tr>
<td></td>
<td>• are able to reflect, test and evaluate the acquired key competencies as well as transfer and implement them in an argumentative way.</td>
</tr>
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<td>Syllabus</td>
<td>Depending on the course</td>
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<td>Teaching and learning methods</td>
<td>e.g. 2 classroom hours</td>
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<tr>
<td>Workload</td>
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<td>self-study: 60 h</td>
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<td>total: 90 h</td>
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<td><strong>Assessment</strong></td>
<td>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.</td>
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### Biology in Ulm: Stress response & resilience of biological systems

**Modules referring to Complementary Area**

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<td>Coordinator</td>
<td>Dean of Studies Biology (Prof. Dr. Marcus Fändrich)</td>
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<td>Syllabus</td>
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<tr>
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<td>Workload</td>
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<td>Private study: 60 h</td>
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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
\[ \begin{itemize} 
\item have knowledge about the fundamentals of the patent system.
\end{itemize} \]

Syllabus This module covers the following subject-specific topics:
\[ \begin{itemize} 
\item Part 1: Rights of use, exhaustion of rights of use using powers, mediate patent infringement, right of prior use, restriction of the effect of the patent, extend of protection, infringement of the protective right, the rights to the invention.
\item Part 2: Novelty, the inventive step, industrial application.
\item Part 3: procedural law, general rules, representation, patent application, procedure up to granting, eliminations of patents, objection, nullity.
\end{itemize} \]

Literature Literature will be provided in the lecture
<table>
<thead>
<tr>
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<th>Lecture (1 hour per week)</th>
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<td><strong>Basis for</strong></td>
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