Georg-August-Universität
Göttingen

Directory of Modules

zu der Prüfungs- und Studienordnung für den konsekutiven Master-Studiengang "Matter to Life" (Amtliche Mitteilungen I Nr. 8/2020 S. 195, zuletzt geändert durch AM I Nr. 34/2021 S. 714)

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I. Master’s degree programme "Matter to Life"

Following the regulations below, at least 120 C must be successfully completed.

The Master's degree programme "Matter to Life" comprises the scientific fields of biophysics, the dynamics of complex systems, physical (elementary) chemistry of life and synthetic biology.

1. Block I (Term 1-3)

Modules worth overall at least 90 C must be successfully completed within the following regulations.

a. Introductory Courses (Term 1-2)

aa. Introductory Courses A

The following introductory courses worth overall 12 C must be successfully completed, provided that these or equivalent modules were not already completed successfully in the course of the Bachelor’s degree programme:

M.MtL.1001: Introduction to Biophysics (6 C, 6 SWS)... 9467

M.MtL.1002: Introduction to Physics of Complex Systems (6 C, 6 SWS).............................. 9468

bb. Introductory Courses B

The following introductory courses worth overall 27 C must be successfully completed:

M.MtL.1005: Advanced Complex Systems and Biological Physics (10 C, 4 SWS)................ 9469

M.MtL.1006: Modern Experimental Methods (6 C, 6 SWS).. 9470

M.MtL.1010: Synthetic Chemistry (6 C, 4 SWS).. 9474

M.MtL.1011: Bioengineering/Synthetic Biology (5 C, 3 SWS).. 9475

b. Advanced Courses (Term 2-3)

Depending on whether or not modules under letter a letters aa had to be completed, a number of modules worth overall at least 28 C or worth overall at least 16 C must be successfully completed; modules that were already successfully completed during the Bachelor’s degree programme must not be taken into account:

B.Phy.5405: Active Matter (3 C, 2 SWS)...9456

B.Phy.5608: Micro- and Nanofluidics (3 C, 2 SWS).. 9457

B.Phy.5613: Soft Matter Physics (3 C, 2 SWS)...9458

B.Phy.5623: Theoretical Biophysics (6 C, 4 SWS)..9459

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B.Phy.5649: Biomolecular Physics and Simulations (4 C, 2 SWS).......... 9464

B.Phy.5658: Statistical Biophysics (6 C, 4 SWS).......... 9465

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M.MtL.1103: Remote Laboratory Work (3 C, 1 SWS).......... 9477

M.MtL.1106: Matter to Life Internship (6 C, 6 SWS).......... 9480

M.MtL.1406: Research seminar Matter to Life (4 C, 2 SWS).......... 9484

M.Phy.1401: Advanced Lab Course I (6 C, 6 SWS).......... 9485

M.Phy.1404: Methods of Computational Physics (6 C, 6 SWS).......... 9486

M.Phy.1405: Advanced Computational Physics (6 C, 6 SWS).......... 9487

M.Phy.5401: Advanced Statistical Physics (6 C, 6 SWS).......... 9488

M.Phy.5610: X-ray Tomography for Students of Physics and Mathematics (3 C, 2 SWS).......... 9489

c. Laboratory Rotations (Term 3)

The following modules/research internships worth overall 26 C must be successfully completed:

M.MtL.1104: Lab Rotation I (13 C).......... 9478

M.MtL.1105: Lab Rotation II (13 C).......... 9479

d. Key Competencies

The following modules worth overall 9 C must be successfully completed:

M.MtL.1201: Ethics in Synthetic Biology (3 C, 2 SWS).......... 9481

M.MtL.1202: Professional Skills in Science (3 C, 2 SWS).......... 9482

M.MtL.1203: Results of the Research Projects (3 C, 2 SWS).......... 9483

2. Block II (Term 4)

Completion of the Master's thesis is worth 30 Credits.

Georg-August-Universität Göttingen Module B.Phy.5405: Active Matter	3 C 2 WLH
Learning outcome, core skills: **Learning objectives**: The students will learn about the basic principles of the physics of active matter as characterized via nonequilibrium statistical physics. Topics will include: physics of micro-swimming, hydrodynamic coordination, continuum description of scalar active matter and motility-induced phase separation, polar active matter and flocking, active liquid crystals (e.g. nematics) and defects, phoretic active matter, activity in enzyme suspensions, and active membranes. **Competences**: This course will give the students a good theoretical understanding of active matter and enable them to follow the state-of-the-art research in the area of active matter.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Active Matter (Lecture)	
Examination: written examination (60 Min.) or oral examination (approx. 30 Min.)	3 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge in statistical physics and hydrodynamics
Language: English	**Person responsible for module:** Prof. Dr. Ramin Golestanian
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Georg-August-Universität Göttingen Module B.Phy.5608: Micro- and Nanofluidics	3 C 2 WLH
Learning outcome, core skills: After successfully finishing this course, students will be familiar with basic hydrodynamics and their applications in biology, biophysics, material sciences and biotechnology. They should know the fundamentals of fluid dynamics on small scales and be able to apply them independently to specific questions.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Lecture	
Examination: Oral exam (ca. 30 min.) or written exam (60 min.) **Examination requirements:** Fluid dynamics, hydrodynamics on the micro- and nanoscale and its applications in biology, biophysics, material sciences and biotechnology; wetting and capillarity; “life” at low Reynolds numbers; soft lithography; fluidics in biology and biophysics, “lab-on-a-chip” applications; Navier-Stokes-Equation	3 C

Admission requirements: none	**Recommended previous knowledge:** Introduction to Biophysics and/or Physics of Complex Systems
Language: German, English	**Person responsible for module:** Prof. Dr. Sarah Köster
Course frequency: every 4th semester; summerterm, in even years	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Georg-August-Universität Göttingen Module B.Phy.5613: Soft Matter Physics	3 C 2 WLH
Learning outcome, core skills: After successfully finishing this course, students will be familiar with fundamental concepts of soft condensed matter physics and will be able to apply them independently to specific questions.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Soft Matter Physics (Lecture)	2 WLH
Examination: Written exam (120 min.) or oral exam (ca. 30 min.) **Examination requirements:** Intermolecular interactions; phase transitions; interface physics; amphiphilic molecules; colloids; polymers; polymer networks; gels; fluid dynamics; self-organization.	

Admission requirements: none	**Recommended previous knowledge:** Introduction to…Biophysics or/and Physics of complex systems or/and Solid State Physics or/and Materials Physics
Language: German, English	**Person responsible for module:** Prof. Dr. Sarah Köster
Course frequency: every 4th semester; summerterm, in odd years	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module B.Phy.5623: Theoretical Biophysics**	6 C 4 WLH

Learning outcome, core skills: **Learning outcome:** Basics of probability theory, Bayes Theorem, Brownian motion, stochastic differential equations, Langevin equation, path integrals, Fokker-Planck equation, Ornstein-Uhlenbeck processes, thermophoresis, chemotaxis, Fluctuation Dissipation Theorems, Stochastic Resonance, Thermal Ratchet, motor proteins, hydrodynamics at the nanoscale, population dynamics, Jarzynski relations, non-equilibrium thermodynamics, neural networks. **Core skills:** The core coal is to teach students fundamental theoretical concepts about stochastic systems in the widest sense, an the application of these concepts the biophysics of biomolecules, cells and populations.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Vorlesung mit Selbststudium Literatur	
Examination: Oral examination (approx. 30 minutes) **Examination requirements:** Derivation of fundamental relations describing stochastic systems, derivation, handling and explanation of differential equations, derivation of analytical and approximative solutions for the various considered problems.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English, German	**Person responsible for module:** Prof. Dr. Jörg Enderlein
Course frequency: every 4th semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 4 - 6; Master: 1 - 4
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module B.Phy.5625: X-ray physics**	6 C 4 WLH

Learning outcome, core skills: Knowledge in: • Radiation-matter interaction • Dosimetry, radiobiology and radiation protection • Scattering experiments: photons, neutrons and electrons • Fundamental concepts in diffraction and Fourier theory • Structure analysis in crystalline and non-crystalline condensed matter • Generation of x-rays and synchrotron radiation • X-rays optics and detection • X-ray spectroscopy, microscopy and imaging After taking the course, students • will integrate fundamental concepts of matter-radiation interaction . • are able to apply quantitative scattering techniques with short wavelength radiation for structure analysis of condensed matter, including problems in solid state, materials, soft matter, and biomolecular physics • are able to plan and carry out x-ray laboratory experiments • are prepared to participate in beamtimes at synchrotron, neutron or free-electron radiation sources • can solve analytical problems in x-ray optics, diffraction and imaging	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: X-ray Physics	

Examination: Written examination (120 minutes) or oral examination (ca. 30 min.) or presentation (ca. 30 min.) **Examination prerequisites:** none **Examination requirements:** • solve problems of the topics mentioned above on a quantitative level, including calculations of structure factor, correlation functions, • applications of Fourier theory to structure analysis and basic solutions to the phase problem, • solve problems of wave optical propagation and diffraction • knowledge about interaction mechanisms and order -of-magnitude estimations, • knowledge about theoretical concepts and experimental implementations of different techniques, • knowledge of laboratory skills (x-ray sources, detection, dosimetry)	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English, German	**Person responsible for module:** Prof. Dr. Tim Salditt

Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 6; Master: 1 - 2
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module B.Phy.5648: Theoretical and Computational Biophysics**	4 C 2 WLH
Learning outcome, core skills: This combined lecture and hands-on computer tutorial focuses on the basics of computational biophysics and deals with questions like "How can the particle dynamics of thousands of atoms be described precisely?" or "How does a sequence alignment algorithm function?" The aim of the lecture with exercises is to develop a physical understanding of those "nano maschines" by using modern concepts of non-equilibrium thermodynamics and computer simulations of the dynamics on an atomistic scale. Moreover, the lecture shows (by means of examples) how computers can be used in modern biophysics, e.g. to simulate the dynamics of biomolecular systems or to calculate or refine a protein structure. No cell could live without the highly specialized macromolecules. Proteins enable virtually all tasks in our bodies, e.g. photosynthesis, motion, signal transmission and information processing, transport, sensor system, and detection. The perfection of proteins had already been highly developed two billion years ago. During the exercises, the knowledge presented in the lecture will be applied to practical examples to further deepen and strengthen the understanding. By completing homework sets, which will be distributed after each lecture, additional aspects of the addressed topics during the lecture shall be worked out. The homework sets will be collected during the corresponding exercises.	**Workload:** Attendance time: 28 h Self-study time: 92 h
Course: Theoretical and Computational Biophysics (Lecture, Exercise)	
Examination: Oral examination (approx. 30 minutes) **Examination requirements:** Protein structure and function, physics of protein dynamics, relevant intermolecular interactions, principles of molecular dynamics simulations, numeric integration, influence of approximations, efficient algorithms, parallel programing, methods of electrostatics, protonation balances, influence of solvents, protein structure determination (NMR, X-ray), principal component analysis, normal mode analysis, functional mechanisms in proteins, bioinformatics: sequence comparison, protein structure prediction, homology modeling, and hands-on computer simulation.	4 C

Admission requirements: none	**Recommended previous knowledge:** • Introduction to Biophysics • Introduction to Physics of Complex Systems
Language: English, German	**Person responsible for module:** Hon.-Prof. Dr. Karl Helmut Grubmüller
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students:	

30	

Georg-August-Universität Göttingen **Module B.Phy.5649: Biomolecular Physics and Simulations**	4 C 2 WLH

Learning outcome, core skills: **Learning objectives:** This combined lecture and hands-on computer tutorial offers the possibility to deepen the knowledge about theory and computer simulations of biomolecular systems, particularly proteins, and can be understood as continuation of the lecture with exercises "Theoretical and Computational Biophysics" (usually taking place in the previous winter semester). During the exercises, the knowledge presented in the lecture will be applied to practical examples to further deepen and strengthen the understanding. By completing homework sets, which will be distributed after each lecture, additional aspects of the addressed topics during the lecture shall be worked out. The homework sets will be collected during the corresponding exercises. **Competencies:** Whereas the winter term lecture with exercises "Theoretical and Computational Biophysics" emphasized the principles of running and analysing simple atomistic force field-based simulations, this advanced course will broaden our view and introduce basic principles, concepts and methods in computational biophysics, particularly required to understand biomolecular function, namely thermodynamic quantities such as free energies and affinities. Further, inclusion of quantum mechanical simulation techniques will allow to also simulate chemical reactions, e.g., in enzymes.	**Workload:** Attendance time: 28 h Self-study time: 92 h

Course: Lecture with Exercises Biomolecular Physics and Simulations	

Examination: Oral examination (approx. 30 minutes) **Examination requirements:** Basic knowledge and understanding of the material covered in the course such as: Free energy calculations, Rate Theory, Non-equilibrium thermodynamics, Quantum mechanical methods (Hartree-Fock and Density Functional Theory), enzymatic catalysis; “handson” computational calculations and simulations	4 C

Admission requirements: none	**Recommended previous knowledge:** B.Phy.5648 Theoretical and Computational Biophysics
Language: English, German	**Person responsible for module:** Hon.-Prof. Dr. Karl Helmut Grubmüller
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module B.Phy.5658: Statistical Biophysics**	6 C 4 WLH
Learning outcome, core skills: **Objectives:** The students will learn basic concepts of statistical biophysics at the molecular, cellular and population level, as well as methods for the theoretical analysis of biophysical systems. **Competences:** After successful participation in the module, students should have working knowledge of basic concepts of statistical biophysics and be able to apply them to selected problems.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Statistical Biophysics (Lecture with integrated problem sessions) *Course frequency:* each winter semester	WLH
Examination: written examination (120 Min.) or oral examination (approx. 30 Min.) **Examination requirements:** Physical principles of biological systems on the molecular, cellular and population level, application of methods from statistical physics to biological and biophysical problems.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge in biophysics and statistical physics
Language: English, German	**Person responsible for module:** Prof. Dr. Stefan Klumpp
Course frequency: every 4th semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module B.Phy.5660: Theoretical Biofluid Mechanics**	3 C 2 WLH
Learning outcome, core skills: The course will discuss the theoretical foundations of fluid mechanics used in the study of biological systems. Important concepts in the mathematical study of fluids will be introduced and employed to investigate blood flow and circulation, the propulsion of organisms and transport facilitated by fluid flow. Students will learn to set up theoretical models for a range of biological systems involving fluids employing the Navier-Stokes equation and appropriate boundary conditions. The course will prepare the students to simplify, assess and analyze models to investigate the intricate role of fluids in biological settings.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Theoretical Biofluid Mechanics (Lecture)	
Examination: Written exam (60 minutes) or oral exam (approx. 30 minutes) **Examination requirements:** Solving Navier-Stokes equation in simple geometry, derive simplified equations from models of fluid flow and transport, explore theoretical models in limiting parameter range and assess prediction in relation to modeled biological system. The exam will be oral, if max. 20 students take part at the first date of the course. Oherwise it will be a written exam.	3 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of calculus and algebra
Language: English, German	**Person responsible for module:** Prof. Dr. Stefan Klumpp Contact: Karin Alim
Course frequency: every 4th semester; Every second Summerterm in Rotation to Microfluidic	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 3 - 6; Master: 1 - 4
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.MtL.1001: Introduction to Biophysics**	6 C 6 WLH
Learning outcome, core skills: After attending this course, students will have basic knowledge about • the build-up of cells and the function of the components • transport phenomena on small length scales, derivation and solution of the diffusion equation • laminar hydrodynamics and its application in biological systems (flow, swimming, motility) • reaction kinetics and cooperativity, including enzymes • non-covalent interaction forces • self-assembly • biological (lipid) membrane build-up and dynamics • biopolymer physics and cytoskeletal filaments, including filament and cell mechanics • neurobiophysics • experimental methods, including state-of-the-art microscopy	**Workload:** Attendance time: 84 h Self-study time: 96 h
Course: Introduction to Biophysics (Lecture) *Contents*: components of the cell; diffusion, Brownian motion and random walks; low Reynolds number hydrodynamics; chemical reactions, cooperativity and enzymes; biomolecular interaction forces and self-assembly; membranes; polymer physics and mechanics of the cytoskeleton; neurobiophysics; experimental methods and microscopy	4 WLH
Course: Introduction to Biophysics (Exercise)	2 WLH
Examination: Written examination (120 min.) or oral examination (approx. 30 min.) **Examination prerequisites:** At least 50% of the homework excercises have to be solved successfully. **Examination requirements:** Knowledge of the fundamental principles, theoretical descriptions and experimental methods of biophysics.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Sarah Köster
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** Master: 1 - 4
Maximum number of students: 30	

Georg-August-Universität Göttingen Module M.MtL.1002: Introduction to Physics of Complex Systems	6 C 6 WLH
Learning outcome, core skills: Sound knowledge of essential methods and concepts from Nonlinear Dynamics and Complex Systems Theory, including practical skills for analysis and simulation (using, for example, the programming language python) of dynamical systems.	**Workload:** Attendance time: 84 h Self-study time: 96 h
Course: Introduction to Physics of Complex Systems (Lecture)	4 WLH
Course: Introduction to Physics of Complex Systems (Exercise)	2 WLH
Examination: written examination (120 Min.) or oral examination (approx. 30 Min.) **Examination prerequisites:** At least 50% of the homework exercises have to be solved successfully. **Examination requirements:** Knowledge of fundamental principles and methods of Nonlinear Physics Modern experimental techniques and theoretical models of Complex Systems theory.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic programming skills (for the exercises)
Language: English	**Person responsible for module:** Prof. Dr. Stefan Klumpp
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** 1
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.MtL.1005: Advanced Complex Systems and Biological Physics**	10 C 4 WLH
Learning outcome, core skills: Students will extend their knowledge in the physics of complex systems and biophysics through the study of selected advanced topics. The emphasis is on connecting textbook-level knowledge with current research though a combination of introductory presentations by the lecturer(s), student presentations, self-study and scientific group discussions. In addition, students will learn and practise to apply the concepts from the introductory lectures on biophysics and physics of complex systems to specific problems in the physics of living systems and to critically assess current scientific literature.	**Workload:** Attendance time: 56 h Self-study time: 244 h
Course: Advanced Complex Systems and Biological Physics (Lecture, Seminar)	4 WLH
Examination: Oral examination (approx. 45 minutes) **Examination prerequisites:** Presentation (approx. 20 min.) **Examination requirements:** In the final oral examination, the students demonstrate their broad knowledge in biophysics and the physics of complex systems and show that they recognize the interrelationships of the areas in biophysics and physics of complex systems and that they can place specific scientific questions within the context of these interrelationships.	10 C

Admission requirements: none	**Recommended previous knowledge:** Introduction to Biophysics, Introduction to Physics of Complex Systems
Language: English	**Person responsible for module:** Prof. Dr. Stefan Klumpp
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** 2
Maximum number of students: 30	

Georg-August-Universität Göttingen Module M.MtL.1006: Modern Experimental Methods	6 C 6 WLH
Learning outcome, core skills: Knowledge about advanced applied optics, radiation-matter interaction, spectroscopy, microscopy and imaging techniques in biophysics After taking this course, students will have quantitative insight into modern experimental techniques for biophysics, in particular optical techniques from basic to advances microscopy including confocal, light sheet and nanoscopy, optical spectroscopy including time-resolved techniques (transient absorption), single molecule techniques (e.g. FCS), electron microscopy, neutron and x-ray diffraction (including protein crystallography), NMR spectroscopy, and X-ray imaging. Students have the competence to reduce the complexity to underlying physics of radiation-matter interaction, to use Fourier-based methods in signal theory, concepts of wave and quantum optics, as well as quantitative data analysis. Hand-on examples of experimental applications and data recording will be introduced by short teaching units in the laboratory along with the courses, and a deeper unit of a 3 days practical in one of the technquies.	**Workload:** Attendance time: 84 h Self-study time: 96 h
Course: Modern Experimental Methods (Lecture, Exercise)	6 WLH
Examination: written examination (120 min.) or oral exam (approx. 30 min.) or presentation (approx. 30 min., 2 weeks preparation time) **Examination requirements:** Theoretical and practical knowledge of modern methods of experimental methods of biophysics.	6 C

Admission requirements: none	**Recommended previous knowledge:** Introduction to Biophysics
Language: English	**Person responsible for module:** Prof. Dr. Tim Salditt
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** 2
Maximum number of students: 15	

Georg-August-Universität Göttingen Module M.MtL.1007: Biochemistry and Biophysics	6 C 7 WLH
Learning outcome, core skills: Molecular Biochemistry and Biophysics of different classes of biomolecules, modern biophysical methods for analysis of biomolecules. Work with state of the art equipment, critical review of current topics in biochemistry, detailed analysis of experiments and corresponding presentation, independent acquisition of expert knowhow from publications.	**Workload:** Attendance time: 98 h Self-study time: 82 h
Course: Biochemistry and Biophysics (Lecture) *Contents*: Spectroscopy of biomolecules (fluorescence, FT-IR, CD, UV/Vis), modern microscopic methods (optical microscopy, scanning probe microscopy), functional analysis of different classes of biomolecules.	1,5 WLH
Course: Biochemistry and Biophysics (Tutorial)	0,5 WLH
Course: Methods course: Biochemistry and Biophysics (Internship)	5 WLH
Examination: Oral examination (approx. 30 minutes) **Examination prerequisites:** regular participation in the lab course and report for the lab course (max. 20 pages) **Examination requirements:** Basics in modern analysis methods used for biomolecules	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. Claudia Steinem
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** 2
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.MtL.1008: Advanced Topics in Matter to Life I**	6 C 6 WLH
Learning outcome, core skills: After successful completion of the module students will be able to understand and apply advanced concepts related to Matter to Life to current research topics. **Core skills:** Students will be able to describe and discuss state-of-the-art problems of relevant to Matter to Life	**Workload:** Attendance time: 84 h Self-study time: 96 h
Course: Advanced Topics in Matter to Life (Lecture) *Contents*: Theoretical or experimental topics relevant to Matter to Life *Course frequency:* each semester	6 WLH
Examination: Written Examination (120 minutes) or Oral Examination (approx.30 minutes) or Presentation (approx. 30 minutes) **Examination requirements:** Advanced experimental techniques or theoretical models in Matter to Life	6 C

Admission requirements: Access must be authorized by the person responsible for the module. They may request the opinion of an authorized examiner in the related field.	**Recommended previous knowledge:** None
Language: English	**Person responsible for module:** Prof. Dr. Stefan Klumpp
Course frequency: every 4th semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** Master: 1 - 3
Maximum number of students: 30	

Additional notes and regulations: Only for Matter to Life Students

Georg-August-Universität Göttingen **Module M.MtL.1009: Advanced Topics in Matter to Life II**	6 C 4 WLH
Learning outcome, core skills: After successful completion of the module students will be able to understand and apply advanced concepts related to Matter to Life to current research topics. **Core skills:** Students will be able to describe and discuss state-of-the-art problems of relevant to Matter to Life	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Course (3C) in the Field of Matter to Life (Lecture) *Contents*: Theoretical or experimental topics relevant to Matter to Life *Course frequency:* each semester	2 WLH
Examination: Written Examination (120 minutes) or Oral Examination (approx.30 minutes) or Presentation (approx. 30 minutes) **Examination requirements:** Advanced experimental techniques or theoretical models in Matter to Life	3 C

Course: Course (3C) in the Field of Matter to Life (Lecture) *Contents*: Theoretical or experimental topics relevant to Matter to Life *Course frequency:* each semester	2 WLH
Examination: Written Examination (120 minutes) or Oral Examination (approx.30 minutes) or Presentation (approx. 30 minutes) **Examination requirements:** Advanced experimental techniques or theoretical models in Matter to Life	3 C

Admission requirements: Access must be authorized by the person responsible for the module. They may request the opinion of an authorized examiner in the related field.	**Recommended previous knowledge:** None
Language: English	**Person responsible for module:** Prof. Dr. Stefan Klumpp
Course frequency: every 4th semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** Master: 1 - 3
Maximum number of students: 30	

Additional notes and regulations: Only for Matter to Life Students

Georg-August-Universität Göttingen Module M.MtL.1010: Synthetic Chemistry	6 C 4 WLH
Learning outcome, core skills: Upon successful completion of the module, students will have a basic understanding of reaction mechanisms in classical synthetic chemistry. They are able to assess the possible reactivity of individual chemical groups and thus establish reaction mechanisms of chemical substances and have an idea of the experimental implementation of these reactions. They can understand reaction mechanisms and assess their relevance.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Synthetic Chemistry *Contents*: The course covers modern chemical reaction mechanisms. Knowledge and mechanistic understanding of important organic reactions will be revised and more in-depth knowledge in the field of organic chemistry will be taught. In addition to basic organic reaction mechanisms bio-inorganic topics will be covered Distance Learning *Course frequency:* each winter semester	4 WLH
Examination: Written Exam (120 min) or Oral Exam (approx 30 min) **Examination requirements:** • basic understanding of reaction mechanisms in classical synthetic chemistry • able to assess the possible reactivity of individual chemical groups • understand reaction mechanisms and assess their relevance	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Claudia Steinem
Course frequency: 1	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** Master: 1
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.MtL.1011: Bioengineering/Synthetic Biology**	5 C 3 WLH

Learning outcome, core skills: Students will obtain an understanding of the concepts and methods of synthetic biology and bioengineering at the molecular to cellular level. They will learn approaches to design biological structures, devices, and systems and will further be introduced to key applications of synthetic biology. Upon successful completion of the module, students have 1. a detailed understanding of quantitative aspects of gene expression and gene regulatory processes; 2. an overview of the main research directions within synthetic biology and the major related technologies; 3. the ability to apply their knowledge to design simple gene circuits themselves; 4. a very good understanding of nonlinear dynamics and dynamic systems in synthetic biological systems and the ability to independently analyze dynamical systems; 5. a good understanding of the role of stochastic processes in synthetic biology and key analytical methods. The students are able to analyze and simulate stochastic processes in the computer model; 6. the ability to assess and evaluate current developments in synthetic biology	**Workload:** Attendance time: 42 h Self-study time: 108 h

Course: Synthetic biology (Lecture) Distance Learning	2 WLH
Course: Synthetic Biology (Exercise)	1 WLH
Examination: Written Examination (120 minutes) or Oral Examination (approx. 25 minutes) **Examination requirements:** biomacromolecules, biological nanostructures, molecular machines and devices, chemical reaction networks, synthetic gene circuits, design of dynamic functions and behaviors, cell-free synthetic biology and artificial cells	5 C

Admission requirements: none	**Recommended previous knowledge:** Some knowledge of Elementary Physical Chemistry, Biophysics and/or Biochemistry
Language: English	**Person responsible for module:** Prof. Dr. Eberhard Bodenschatz Prof. Dr. Friedrich Simmel (TU München)
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** Master: 1
Maximum number of students:	

30	

Georg-August-Universität Göttingen **Module M.MtL.1103: Remote Laboratory Work**	3 C 1 WLH

Learning outcome, core skills: An introduction to laboratory experiments performed remotely. Students will collaborate to operate a research microscope in person and remotely. They will collect data, analyse the resultant images and report their results. By the end of the module students will: Be familiar with the workings of a research microscope Understand and be compentent in using video particle tracking and image analysis Develop a data analysis pipeline Be able to collaborate in remote teams	**Workload:** Attendance time: 14 h Self-study time: 76 h

Course: Remote Laboratory Work (Practical course)	
Examination: Written Report (max. 10 pages) **Examination requirements:** A written report demonstrating the successful use of advanced experimental methods to analyse systems relevant to Matter to Life.	3 C

Admission requirements: None	**Recommended previous knowledge:** None
Language: English	**Person responsible for module:** Prof. Dr. Sarah Köster
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** Master: 1 - 2
Maximum number of students: 10	

Georg-August-Universität Göttingen Module M.MtL.1104: Lab Rotation I	13 C
Learning outcome, core skills: By working under supervision of a PhD student on a current scientific research project, students will be familiarized with an advanced topic in the field of Biophysics/Physics of Complex Systems. They will learn to successfully perform a sub-task within a larger research project and finally present the results to a professional audience. Students will be able to organize, conduct, evaluate and present small, manageable projects in the field of Biophysics/Physics of Complex Systems, obeying the rules of good scientific practice.	**Workload:** Attendance time: 0 h Self-study time: 390 h
Course: Lab Rotation in Biophysics and Physics of Complex Systems	WLH
Examination: written report (max. 10 pages) **Examination requirements:** Methods for in-depth familiarization in a scientific field of work, critical review of literature, scientific presentation, good scientific practice.	13 C

Admission requirements: none	**Recommended previous knowledge:** Introduction to Biophysics, Introduction to Physics of Complex Systems
Language: English	**Person responsible for module:** Prof. Dr. Stefan Klumpp
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** 3
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.MtL.1105: Lab Rotation II**	13 C
Learning outcome, core skills: By working under supervision of a PhD student on another current scientific research project, students will be familiarized with another advanced topic in the field of Biophysics/Physics of Complex Systems. They will learn to successfully perform a sub-task within a larger research project and finally present the results to a professional audience. Students will be more able to organize, conduct, evaluate and present small, manageable projects in the field of Biophysics/Physics of Complex Systems, obeying the rules of good scientific practice.	**Workload:** Attendance time: 0 h Self-study time: 390 h
Course: Lab Rotation in Biophysics and Physics of Complex Systems II	WLH
Examination: written report (max. 10 pages) **Examination requirements:** Methods for in-depth familiarization in a scientific field of work, critical review of literature, scientific presentation, good scientific practice.	13 C

Admission requirements: none	**Recommended previous knowledge:** Introduction to Biophysics, Introduction to Physics of Complex Systems
Language: English	**Person responsible for module:** Prof. Dr. Stefan Klumpp
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** 3
Maximum number of students: 15	

Georg-August-Universität Göttingen Module M.MtL.1106: Matter to Life Internship	6 C 6 WLH
Learning outcome, core skills: After successful completion of the module, students should be competant to work within a research group on a topic related to matter to life. The students should independently familiarise themselves with the group's research topic and be able to perform research under supervision and as part of a team. The results of this work should be presented as a talk or poster.	**Workload:** Attendance time: 84 h Self-study time: 96 h
Course: Matter to Life Internship (Internship)	6 WLH
Examination: Poster Presentation or Oral Presentation (30 minutes) **Examination prerequisites:** Internship **Examination requirements:** Familiarity with and ability to apply advanced techniques to address research questions related to matter to life.	6 C

Admission requirements: This module can be selected only on the recommendation of a lecturer.	**Recommended previous knowledge:** None
Language: English	**Person responsible for module:** Prof. Dr. Sarah Köster
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** Master: 2
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.MtL.1201: Ethics in Synthetic Biology**	3 C 2 WLH
Learning outcome, core skills: Upon successful completion of the module, students will have a basic understanding of relevant ethical issues in Synthetic Biology. They will be able to explain and discuss ethical difficulties within the discipline as well as to interested laypersons and contribute to the social discourse on these topics.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Ethics in Synthetic Biology (Lecture) Distance Learning	2 WLH
Examination: Written examination (120 minutes) **Examination requirements:** biosafety; dual-use research; cultural concepts of natural and artificial, living and non-living; economic aspects of synthetic biology, patentability; mechanisms of participation and societal decision-making related to synthetic biology	3 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Eberhard Bodenschatz
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** 1
Maximum number of students: 30	

Georg-August-Universität Göttingen Module M.MtL.1202: Professional Skills in Science	3 C 2 WLH
Learning outcome, core skills: The students will be trained in scientific writing and oral presentation skills which will enable them to adequately structure and compose scientific texts, particularly for written and oral reports on experimental and theoretical findings in the field of their studies. They will be introduced to the principles of good scientific practice and measures required to secure ethical standards in science. In addition, the students will gain an understanding of laboratory safety principles and knowledge of measures and procedures to work safely in a research laboratory.. Other topics covered include intellectual property, commercialisation of ideas and critical evaluation of the scientific literature.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Professional skills in science (Key competence)	2 WLH
Examination: Oral presentation (approx. 30 min.), not graded **Examination requirements:** Demonstration of writing competence, oral presentation skills, lab safety rules and regulations in a scientific context in the English language at an advanced level.	3 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Stefan Klumpp Köster, Sarah, Prof. Dr.
Course frequency: once a year	**Duration:** 2 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** Master: 1 - 2
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.MtL.1203: Results of the Research Projects**	3 C 2 WLH
Learning outcome, core skills: The specific skills practiced in the seminar include efficient and concise presentation of own scientific results in English, development of a differentiated scientific vocabulary, and the critical discussion of the scientific data in the broader context of their relevance for current research.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Results of the Research Projects (Key competence)	2 WLH
Examination: oral presentation (approx. 20 min.), not graded **Examination requirements:** Demonstration of adequate oral presentation skills including the critical discussion and evaluation of the data presented.	3 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Sarah Köster Prof. Dr. Stefan Klumpp
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** 3
Maximum number of students: 15	

Georg-August-Universität Göttingen Module M.MtL.1406: Research seminar Matter to Life	4 C 2 WLH
Learning outcome, core skills: After successful completion of the module, students should present complex lines of reasoning and evaluate own and others' presentations in critical discussion.	**Workload:** Attendance time: 28 h Self-study time: 92 h

Course: Research seminar Matter to Life (Seminar)	2 WLH
Examination: Oral Presentation (approx. 60 minutes) **Examination prerequisites:** regular participation **Examination requirements:** Preparation of complex topics for presentation and scientific discussions.	4 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Stefan Klumpp
Course frequency: every 4th semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: once	**Recommended semester:** 1 - 3
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.Phy.1401: Advanced Lab Course I**	6 C 6 WLH
Learning outcome, core skills: After successful completion of the module, students have • familiarised themselves independently with complex issues, • performed experimental tasks under guidance in a team, • and have written scientific protocols within good scientific practice.	**Workload:** Attendance time: 84 h Self-study time: 96 h
Course: Advanced Lab Course I	
Examination: Oral examination (approx. 30 minutes) **Examination prerequisites:** 4 successful performed experiments. **Examination requirements:** Advanced experimental methods for solving physical problems.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English, German	**Person responsible for module:** StudiendekanIn der Fakultät für Physik
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** 1
Maximum number of students: not limited	

Georg-August-Universität Göttingen Module M.Phy.1404: Methods of Computational Physics	6 C 6 WLH
Learning outcome, core skills: After successful completion of the module students will be familiar with the key methods and algorithms of computational physics. Students will be able to select and deploy appropriate computational approaches in order to model and analyse a range of classical and quantum systems.	**Workload:** Attendance time: 84 h Self-study time: 96 h
Course: Computational lab course	2 WLH
Course: Methods of Computational Physics (Lecture)	4 WLH
Examination: written (120 min.) or oral exam (approx. 30 min.) **Examination prerequisites:** Successful completion of 6 computational projects **Examination requirements:** Projects may include: Monte Carlo for phase transitions, rare event simulations, exact numerics for quantum systems, quantum Monte Carlo, simulations of disordered/glassy systems.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of equilibrium statistical mechanics and 1-particle quantum mechanics.
Language: English, German	**Person responsible for module:** Prof. Dr. Fabian Heidrich-Meisner
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** 1 - 3
Maximum number of students: 30	

Georg-August-Universität Göttingen Module M.Phy.1405: Advanced Computational Physics	6 C 6 WLH
Learning outcome, core skills: After successful completion of the module students should be familiar with the complete project cycle of advanced computational physics work. Students will be able to build and refine appropriate models for solutions of specific physical problems, select and implement advanced computational approaches using both existing software and own codes, and analyse the resulting data.	**Workload:** Attendance time: 84 h Self-study time: 96 h
Course: Computational lab course	
Examination: Oral examination (approx. 30 minutes) **Examination prerequisites:** Successful completion of 3 problem-driven computational projects (50% of the achievable score in each project) **Examination requirements:** Projects may include: Monte Carlo for phase transitions, rare event simulations, exact numerics for quantum systems, quantum Monte Carlo, simulations of disordered/glassy systems.	6 C

Admission requirements: none	**Recommended previous knowledge:** • *Methods of Computational Physics* • *Advanced Statistical Physics* • *Advanced Quantum Mechanics*
Language: English, German	**Person responsible for module:** Prof. Dr. Marcus Müller
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** 2
Maximum number of students: 30	

Georg-August-Universität Göttingen Module M.Phy.5401: Advanced Statistical Physics	6 C 6 WLH
Learning outcome, core skills: After successful completion of the module students will be familiar with the core concepts and mathematical methods of statistical physics both in and out of equilibrium. Students will be able to model and analyse interacting or fluctuation-dominated systems using methods from statistical physics, and be aware of a range of application domains including soft matter, biophysics and network dynamics.	**Workload:** Attendance time: 84 h Self-study time: 96 h
Course: Advanced Statistical Physics (Lecture)	4 WLH
Course: Advanced Statistical Physics (Exercise)	2 WLH
Examination: written (120 min.) or oral exam (approx. 30 min.) **Examination prerequisites:** At least 50% of the homework of the excercises have to be solved successfully.	

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of statistical mechanics of equilibrium
Language: English	**Person responsible for module:** Prof. Dr. Matthias Krüger
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** 1
Maximum number of students: 80	

Georg-August-Universität Göttingen **Module M.Phy.5610: X-ray Tomography for Students of Physics and Mathematics**	3 C 2 WLH
Learning outcome, core skills: Knowledge in: • Principles of Radiography and Tomography • Radiation Safety / Reconstruction Algorithms and practical Implementation of algorithms, testing of algorithms, cone beam reconstruction • phase retrieval and phase contrast • treatment of artefacts, filters • quantitative assessment of image quality • image segmentation Taking the course students will be able to : • operate laboratory equipment, perform tomographic alignment and to setup tomographic scans • to reconstruct data based on Matlab toolbox (Salditt Group) • to analyse data, perform segmentation	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Course: X-ray Tomography *Contents*: • one week self-study in preparation based on tutorials and the textbook by Salditt/ Aspelmeier /Aeffner (De Gruyter 2017), a full one week course with • morning lectures including Matlab tutorials • afternoon tomography practice in the laboratory using three different instruments (liquid metal jet, rotating anode, high energy), • overnight scans • Matlab-based reconstruction (Server IRP, Toolbox Salditt Group)	
Examination: Oral examination (approx. 45 minutes) **Examination requirements:** • Presentation of a successful scan and reconstruction, • oral discussion of the data and analysis	3 C

Admission requirements: none	**Recommended previous knowledge:** Electrodynamics, Matlab/Python
Language: English	**Person responsible for module:** Prof. Dr. Tim Salditt
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** 1 - 4

Maximum number of students: 15	

Additional notes and regulations: 1 week in October before start of lectures. Partial overlap with Physicists' tomography course.