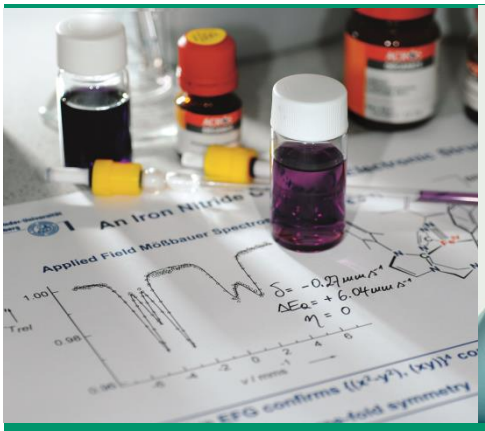
FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

NATURWISSENSCHAFTLICHE
FAKULTÄT

Modulhandbuch

Master Molecular Science



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Modulhandbuch für den
Masterstudiengang Molecular Science

Department Chemie und Pharmazie
Friedrich-Alexander-Universität
Erlangen-Nürnberg

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Master program in Molecular Science

The Master program in Molecular Science at the FAU Erlangen-Nuremberg can be started in the winter or in the summer term. The usual period for completing the M.Sc. is one and a half years (3 semesters), after which a Ph.D. program can be started.

The Master program is based on the Bachelor program in Molecular Science at the FAU. It provides an advanced education with the goal of preparing students for a career in research. The courses within the Master program in Molecular Science are held in English, few exceptions are marked.

To enter the Master's program, applicants must have completed a Bachelor's degree with high academic standing from a recognized university. Applicants apply online through the Master application portal of the FAU http://www.uni-erlangen.org/studying/degree-programmes/application-master-degree.shtml

The Master program is constructed in separate modules. It includes one mandatory module (equivalent to 30 credit points) which can be Molecular Nano Science or Drug Discovery, one mandatory elective module (equivalent to 15 credit points), one elective module (equivalent to 15 credit points). Three small modules (10 CP each), scientific methods, repetition and current aspects in molecular science prepare for the final exams in the main modules and for the master thesis (equivalent to 30 credit points). All modules add up to 120 credit points as requested for a 2 years bachelors program. Usually, during the first two semester of the program the mandatory module, the mandatory elective module and the elective module are completed. The third semester is reserved for the three preparatory modules and exams are usually taken at the end of the third semester. The master thesis is completed during the fourth semester.

As mandatory elective module one out of five (MSM-ME) has to be chosen. The elective module can be either a second mandatory elective module, one of the elective module (MSM-E) of the M.Sc. program in Chemistry, or a free choice of courses offered at the Department of Chemistry and Pharmacy, while one third of the courses might be key qualifications. The Master thesis finalizes the scientific education of the M.Sc. program. The student should proof his/her ability to solve a scientific problem independently under the guidance of an experienced supervisor.

Courses offered in the Department of Chemistry and Pharmacy cover a wide range of subjects and are offered in general once a year, i.e., either in the winter term (WS) or in the summer term (SS). Details can be found in the description of the respective modules. The exams have to be completed prior to the beginning of the Master thesis work.

The configuration of the individual Master program has to be registered in StudOn. The choice of modules should be reported within the first week of the first semester. For the elective module, the choice has to be confirmed by the responsible persons of the module and the students' dean.

Master students might study some periods abroad according to prior agreement with the Students' Dean of the Department Chemistry and Pharmacy.

An overview of the Master program and various case studies for the composition of the Master studies are given below.

The academic achievements are assessed by ECTS-credits. The correlation of SWS (1 SWS corresponds to 1 hour teaching per week) and ECTS-credits for the Mandatory Modules or Mandatory Elective Modules and Elective Modules or is given by the following factors:

Lectures *):	1 SWS x 1,0 – 1,25
Seminars, exercises:	1 SWS x 1
Lab course:	1 SWS x 0,6 – 1

*) For the Elective Modules, we correlate lecture hours by a factor of 1.25 – 1.5.
For the workload one academic hour (45 min) is calculated as a full hour (60 min).

The attendance time is calculated on a lecture period of 15 weeks (winter term) and 14 weeks (summer term), respectively. Therefore 1 SWS is equivalent to 15 hours or 14 hours, respectively. The workload of a module is calculated with 30 hours per ECTS credit on average. E.g., a module of 15 ECTS-credits is generally equivalent to an overall workload of 450 hours.

Please check the timetable (www.univis.uni-erlangen) or the student web pages for offered courses.

Advisors in the Molecular Science Master program
Department of Chemistry and Pharmacy
Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)

► **Students' Dean for the programs Chemistry and Molecular Science**
(Assistance and advice in the study programs Chemistry and Molecular Science)

Prof. Dr. Jürgen Schatz, Lehrstuhl für Organische Chemie I,
Department Chemistry and Pharmacy, University of Erlangen-Nuremberg
Henkestraße 42, 91054 Erlangen, Office/Room 151a
Tel.: 09131 85 25766; mail: juergen.schatz@fau.de

► **Head of the audit committee Chemistry and Molecular Science**
(Exam related enquiries in the study programs Chemistry and Molecular Science)

Prof. Dr. Thomas Drewello, Professur für Physikalische Chemie II,
Department Chemistry and Pharmacy, University of Erlangen-Nuremberg
Egerlandstr. 3, 91058 Erlangen, Office/Room P 3.54
Tel.: 09131 85-28312; mail: Thomas.Drewello@fau.de

► **Advisor for the study programs in Chemistry and Molecular Science**
(Organization of the study programs Chemistry and Molecular Science; assistance and advice)

Dr. Almut Ruyter, Student-Service-Center Chemistry and Molecular Science,
Department Chemistry and Pharmacy, University of Erlangen-Nuremberg
Egerlandstr*. 3, 91058 Erlangen, Office/Room* 0.113-9 (Building C) Tel.: 09131 85 67480;
mail: almut.ruyter@fau.de

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Mandatory modules

1	**Module Name**	**MSM-nano: Molecular Nanoscience (Mandatory Module Molecular Nanoscience)**	**30 CP**
2	**Courses**	**Mandatory courses (A):** **Lectures & Seminars:** A1. Supramolecular Chemistry I (2 L) A1. Supramolecular Chemistry II (2 L) A2. Nanoparticles and nanostructured thin films I 1 L) A2. Nanoparticles and nanostructured thin films II (1 L) A3.Nanoprobes I (2 L) A3.Nanoprobes II (2 L) A4. Molecular Nanoscience – SEMINAR I (2 S) A4 Molecular Nanoscience – SEMINAR II (2 S) A5.LAB COURSE Molecular Nanoscience (7 LAB) **Elective courses (B) (in total 9 SWS *):** Courses of the student's choice related to the module and with approval by the representative of the study course MSM-E Lecture: 8 MSM-E Seminar: 1 B1:Characterization of nanosized systems (2L) B2: Organic thin films (2L/1S) B3: Formation and characterization of supramolecular nanostructures (2L/1S) B4: Carbon allotropes – synthesis, properties and applications (2L) B5: Nanoscale semiconductor materials (2L) Please check UnivIS for further lectures/seminars *) choose a minimum of 4 lectures (à 2L) and 1 seminar (1S)	
3	**Module Coordinator**	Prof. Dr. A. Hirsch	
4	**Teaching Staff**	A1 Prof. Dr. Hirsch / Prof. Dr. Schatz A2 Prof. Dr. Bachmann A3 Prof. Dr. Fink A4 Prof. Dr. Gröhn (coordination) and Profs. Fink, Hirsch, Tykwinski, PD Marbach A5 Professors in Organic, Inorganic and Physical Chemistry B1 Prof. Dr. Guldi B2 Prof. Dr. Fink B3 Prof. Dr. Gröhn B4 Prof. Dr. Tykwinski B5 Prof. Dr. Bachmann	
5	**Syllabus Outline**	**A1:** Concepts in supramolecular chemistry; host-guest chemistry; energetics of supramolecular complexes: experimental methods; templates and self-assembly. Molecular devices. Supramolecular catalysis: principles of supramolecular catalysis, supramolecular metal catalysis, self-assembled catalysts, metal-free catalysis, enzyme mimics, antibodies, imprinted polymers. **A 2:** Synthesis of 1-, 2- and 3-dimensional inorganic nanomaterials. Systematic approaches towards nanoparticles of defined size and structure and with tailored properties. Optical, electronic and mechanical properties. Sensing, biomedical and semiconductor device applications. **A3:** Nanoscaled systems, general issues of microscopic techniques; experimental techniques with nanometer resolution: STM/AFM and related scanning probes; light microscopy, confocal microscopy; elec-	

		tron microscopy (SEM, TEM, FEM/FIM, LEEM, PEEM), x-ray microscopy and synchrotron radiation. **A4:** Specific topics in synthesis and analysis of specific molecule-based nanoscale objects **A5:** focused topics in fundamental and applied research on nanoscale materials – available topics, see website http://www.chemie.uni-erlangen.de/dcp/studium/studiengaenge/molecular-science/regularien-formulare/laufzettel/ → Laufzettel-Praktikum
6	**Educational goals and Learning outcome**	The students are able • to explain the fundamental chemical and physical properties of nanoscale materials • to distinguish and to compare some properties, structure and applications of different nanomaterials • to describe and to evaluate the major concepts in supramolecular chemistry • to explain the general issues of selected microscopic techniques and to evaluate their applications to different materials • to prepare and to characterize nano-sized samples (thin films, nanotubes, molecular materials, nanoparticles) using selected experimental methods and techniques (includes experiment planning and data evaluation) • to interpret and to critically summarize measurements results in written (lab report in paper-style format) and partly oral form • to get used to perform research-related experiments within a smaller team.
7	**Prerequisites**	Admission to the M. Sc. program Molecular Science or Chemistry
8	**Intended stage in the degree course**	Mandatory module for Molecular Nanoscience semester 1. and 2.
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Nanoscience
10	**Assessment and examinations**	Portfolio: PL: Oral examination (45 min, 3 examiners); LAB (SL, AP)
11	**Calculation of the grade for the module**	100% from oral examination
12	**Frequency of offer**	Annually / start of studies is available in summer and winter term Courses “I” in winter term, courses “II” in summer termA5: LAB Course upon individual appointments with respective contact persons B1 – B3: winter term B4/B5: summer term
13	**Workload**	900 hours (includes 450 hours private studies)
14	**Duration**	2 semesters
15	**Language**	english
16	**Preparatory reading / reading list**	Manuscripts for most lectures available online check respective information and docket (“Laufzettel”) on the Molecular Science web page

1	**Module Name**	**MSM-life Drug Discovery (Mandatory Module Molecular Lifescience)**	**30 CP**
2	**Courses**	Mandatory courses: Seminars: Drug Discovery - SEMINAR (7 SEM) Drug Discovery - LAB course (23 LAB), 10 week block lab project in one of the participating research groups (see 4.) with Seminar Research projects (1 S): oral presentation (20 min, plus discussion) Seminar Journal club (group seminar in one of the research groups) (2 S)	
3	**Module Coordinator**	Prof. Dr. P. Gmeiner	
4	**Teaching Staff**	SEM:. Profs. Backert, Burkovski, Burzlaff, Clark, Eichler, Gmeiner, Heinrich, Ivanovic-Burmazovic, Koch, Mokhir, Muller, Nitschke, Schatz, Stadler, Winkler, Drs. Beierlein, Einsiedel, Hennemann, Lanig, Löber, Tschammer LAB Course Profs. Profs. Backert, Büttner, Burkovski, Burzlaff, Clark, Eichler, Friedland, Gmeiner, Heinrich, Ivanovic-Burmazovic, Koch, Mokhir, Muller, Nitschke, Prante, Schatz, Stadler, Winkler	
5	**Syllabus Outline**	**Drug Discovery - SEMINAR** Genomics, transcriptomics, proteomics; in-vitro assay systems, assay technology; target screening and drug production in plants, drug screening and production in yeast; experimental structural biology; chemoinformatics; molecular modeling: molecular dynamics simulation, force-fields, modeling of proteins, protein-ligand docking; drug synthesis and combinatorial chemistry; redox-active metal complexes, metalloenzyme inhibitors; stereochemistry in drug design; organic reactions in medicinal chemistry; drug metabolism; peptidomimetics; **LAB Course** Project course: Lab projects focusing on the modern research issues in one of the participating research groups. Seminar research projects: students reports on lab projects. Discussions on recent publications in the field of drug discovery (within the respective research units).	
6	**Educational goals and Learning outcome**	The students are able • to understand the basic and advanced principles of medicinal chemical, molecular biological and computer-chemistry based applications in the field of modern drug design research • to utilize modern experimental techniques to prepare and characterize various samples within the lab project • to apply modern simulation techniques for the modeling of proteins • to interpret and to critically summarize experimental results in written form (lab report), and to present and discuss these results within the research group or in front of a student audience • to participate in planning, developing and executing of experimental routes for the synthesis of drugs • to judge and to discuss in oral form their research results in the field of drug discovery in comparison to recent publications.	
7	**Prerequisites**	Admission to the M. Sc. program Molecular Science or Chemistry	
8	**Intended stage in the degree course**	Mandatory module for M.Sc. Molecular Lifescience semester 1. and 2.	
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Lifescience	
10	**Assessment and examinations**	Portfolio: PL Oral examination (O45 min, 3 examiners) LEC (PL)	

		LAB (PL, AP) Lab course protocol (without explicite mark) + oral presentation of research project (20 min + discussion);
11	**Calculation of the grade for the module**	PL: O45 (66 %) LEC (PL) (17 %) LAB (PL, AP) (17 %)
12	**Frequency of offer**	Annually / start of studies is strongly recommended in winter term
13	**Workload**	900 hours (includes 450 hours private studies and 50 contact hours)
14	**Duration**	2 semesters
15	**Language**	English
16	**Preparatory reading / reading list**	Manuscripts are available on StudOn additional reading, e.g. G. Klebe, Drug Design: Methodology, Concepts, and Mode-of-Action, Springer 2013

Mandatory Elective Modules

1	**Module Name**	**MSM-ME1 Molecular Synthesis**	**15 CP**
2	**Courses**	A. LAB course Molecular Synthesis either in Inorganic or Organic Chemistry) (6 Lab/1 S) Lectures & Seminars B: Advanced Inorganic Chemistry 1 (2L/1S) C: Advanced Inorganic Chemistry 2 (1L) choice of 1 course from C1: Bioinorganic chemistry I (1L) C2: Metals in medicine (1L) C3: Nanoparticles and nanostructured thin films (1L) C4: Modern X-Ray structure determination of single crystals D: Advanced Organic Chemistry 1 (2L) E: Advanced Organic Chemistry 2 (2L) choice of 1 course from E1: Organocatalysis (2L) E2: Chemie der Naturstoffe (2L) E3: Radical Chemistry (2L) Check for other alternatives in UnivIS NB: no overlap with courses in Mandatory Module allowed	
3	**Module Coordinator**	Prof. Dr. A. Hirsch	
4	**Teaching Staff**	A: Professors in Inorganic and Organic Chemistry B: Ivanovic-Burmazovic/Prof. Dr. Meyer C1: Prof. Dr. Burzlaff C2: Prof. Dr. Burzlaff C3: Prof. Dr. Bachmann C4: Dr. F. Heinemann D: Professors in Organic Chemistry E1: Prof. Dr. Tsogoeva E2: Dr. Speck E3: Prof. Dr. Heinrich	
5	**Syllabus Outline**	**A:** Advanced chemical synthesis and molecular analysis **B:** Inorganic and coordination chemistry principles; application of spectroscopic methods; advanced reaction mechanisms and experimental methods; important catalytic processes driven by metal complexes; design and synthesis of catalysts, physiologically active substances and new materials based on transition metals compounds **D:** Modern synthetic methods in organic chemistry: pericyclic reactions, heterocycle syntheses, modern catalytic methodologies (metal-, organo- and biocatalysis), strategies in stereoselective synthesis **C1:** Metal binding to proteins and DNA; functions of metal ions in enzymes; O_2 transport, storage and activation; electron transfer in proteins; heme and non-heme iron containing oxygenases; zinc peptidases and proteases; superoxide dismutases; copper containing enzymes; biological function of nickel, molybdenum and tungsten; concepts and synthesis of model complexes; basics of Photosynthesis **C2:** Platinum based anticancer drugs; Ruthenium and gold based metallotherapeutics; silapharmaca; Li therapeutics; boron neutron cap-	

		ture therapy; MnSOD; insulin mimetic vanadium containing compounds; magnetic resonance imaging (MRI); cobalamin; metal poisoning; Hg in the biosphere; metallotherapeutic arsenic compounds; technetium radiodiagnostics; antimony in medicine; bismuth based pharmaceuticals **C3:** Synthesis of 1-, 2- and 3-dimensional inorganic nanomaterials. Systematic approaches towards nanoparticles of defined size and structure and with taylored properties. Optical, electronic and mechanical properties. Sensing, biomedical and semiconductor device applications. **C4:** Fundamentals of crystallization; polymorphism; structural description of crystals, crystal systems, unit cell, symmetry and symmetry elements, space groups; diffraction power of crystals, diffraction conditions, structure factor; generation of X-rays, single crystal diffractometers, data collection, data reduction; structure solution and refinement, problems and pitfalls, anomalous dispersion and absolute structure, interpretation of results, graphical representations, data bases. **E1:** General concepts of organocatalysis. Enamine/iminium ion activation by Lewis basic amines. Non-covalent catalysis with ureas, thioureas and diols. Brønsted- and Lewis-acid catalysis. Phase-transfer catalysis. Bi- and multi-functional catalysts. Iminium/Enamine cascade catalysis. Organocatalytic domino reactions; natural product and chiral drug synthesis. **E2:** Structure, isolation and structure elucidation of natural products; biosynthesis and degradation of carbon hydrates, lipids, peptides and terpenoids; biological and medicinal aspects of tetrapyrrols and alkaloids; technical synthesis of vitamins **E3:** Radical reactivity; time scales and radical clock experiments; electrophilic and nucleophilic radicals; radical initiators; radical generation by oxidation or reduction; tin hydrides and modern replacements; atom and group transfer reactions; generation of various carbon-centered radicals; generation of oxygen- and nitrogen-centered radicals.
6	**Educational goals and Learning outcome**	The students are able • to understand and to explain the principles of advanced chemical synthesis routes and molecular analysis in organic and inorganic chemistry • to understand the functionality of various molecular systems • to participate in planning, developing and executing of experimental routes for the synthesis of more complex molecular systems • to characterize molecular samples (natural compounds, e.g., peptides or vitamins, or metal-based drugs) using modern experimental methods and techniques • to interpret and critically summarize experimental results in written form (lab report in paper-style format) • to work in smaller research teams (team ability).
7	**Prerequisites**	Admission to the M. Sc. program Molecular Science or Chemistry
8	**Intended stage in the degree course**	Mandatory elective module (Wahlpflichtmodul) or Elective module (Wahlmodul), semester 1 - 3
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Nanoscience M.Sc Molecular Lifescience
10	**Assessment and examinations**	Portfolio: LAB (SL, AP) Lab course protocol(s) without marks + oral examination (45 min) 2 Examiners
11	**Calculation of the grade for the module**	100% from oral examination
12	**Frequency of offer**	annually/ start of studies is available in summer and winter term A: upon appointment with contact persons B & D: winter term E1/E2: summer term; E2 also winter term; E3: winter

		term C1/C2/C3: winter term
13	**Workload**	450 hours (includes about 240 hours private studies)
14	**Duration**	2 semesters
15	**Language**	English (except for D2, which is held German)
16	**Preparatory reading / reading list**	Manuscripts available online for most lectures Check respective information and docket (“Laufzettel”) on the Molecular Science web page

1	**Module Name**	**MSM-ME2 Theory**	**15 CP**
2	**Courses**	A: Quantum Chemistry I (2L/1Ex) B: Modeling of catalytic processes (2L/1S) C: Modeling of macromolecular compounds (2L/1S) D: Scientific programming (1S/1Ex) E: Handling of computer systems in science (1S/1Ex) F: Practical training in computer chemistry (2Lab)	
3	**Module Coordinator**	Prof. Dr. A. Görling	
4	**Teaching Staff**	A: Prof. Dr. Görling B: Prof. Dr. Meyer/Prof. Dr. Görling C: Prof. Dr. Clark, Prof. Dr. Zahn D, E, F: Dr. Hesselmann, PD Dr. Hieringer, Dr. Neiß	
5	**Syllabus Outline**	**A:** Quantum Chemistry I: Consolidation of the mathematical backgrounds in quantum chemistry, Hertree-Fock method, configuration interactions; density functional theory and its application to molecular systems **B:**. Modeling of catalytic processes Introduction to the theoretical concepts and methods to study catalytic processes: energetic, kinetics and dynamics of adsorbates, reactivity of surfaces; transition state theory, microkinetic modeling, kinetic Monte-Carlo techniques, molecular dynamics C**:** Modeling of macromolecular compounds Basic ideas of modeling biological and technical polymers; Monte-Carlo-techniques, quantitative structure-property relationships; molecular dynamics in polymers; homology modeling **D:** Scientific programming using FORTRAN **E:** Introduction to Linux systems; F: Lab course: application of modern modeling techniques to investigate molecular systems	
6	**Educational goals and Learning outcome**	The students • get experience with advanced knowledge and techniques in theoretical chemistry • are able to utilize advanced computer-based techniques to model research related problems in the field of chemistry, biochemistry, catalysis and material science • learn to operate Linux-based and large-scale computing systems • are able to summarize and to interpret theoretical calculations in written form (lab report).	
7	**Prerequisites**	Admission to the M. Sc. program Molecular Science or Chemistry	
8	**Intended stage in the degree course**	Mandatory Elective Module (Wahlpflichtmodul) or Elective Module (Wahlmodul), semester 1 - 3	
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Science; M.Sc. Chemistry	
10	**Assessment and examinations**	Portfolio: Depending on the choice of the module LAB (SL, AP)Lab course protocol(s) without marks + oral examination (45 min, 2 examiners)	
11	**Calculation of the grade for the module**	100% from oral examination	
12	**Frequency of offer**	Annually A: winter term B: summer term C: summer term D: winter term E: summer term F: winter term	
13	**Workload**	450 hours (includes about 240 hours private studies)	

14	**Duration**	2 semesters
15	**Language**	English
16	**Preparatory reading / reading list**	Manuscripts available for most Lectures

1	**Module Name**	**MSM-ME3 Physical Chemistry**	**15 CP**
2	**Courses**	Mandatory courses: Lab course: A. Lab course (7/8 experiments from advanced PC lab; 4 experiments may be replaced by a project course in one of the PC work groups – with prior approval of the lab coordinator (7 Lab)) Lectures/seminars (please choose additional 6 L and 2 S), e.g. B1: Characterization of Nanosized Systems (2L) B2: Organic thin films (2L/1 S) B3: Modern Methods in Mass Spectrometry (2L/1S) B4: Symmetry and Group Theory (2L/1S) B5: Interface Science and Catalysis (2L/1S) B6: Solar Energy conversion (2L) B7: Formation and characterization of supramolecular nanoparticles (2L/1S) Please check UnivIS for further lectures/seminars NB: no overlap with courses in Mandatory Module allowed	
3	**Module Coordinator**	Prof. Dr. R. Fink	
4	**Teaching Staff**	A. Dr. G. Sauer (Physical Chemistry I) B1:Prof. Dr. Guldi B2: Prof. Dr. Fink B3:Prof. Dr. Drewello B4:Prof. Dr. Libuda B5:Prof. Dr. Libuda B6: Prof. Dr. Guldi B7: Prof. Dr. Gröhn	
5	**Syllabus Outline**	**A:** Advanced course lab experiments and/or lab project close to actual research topics **B1:** Fullerenes; carbon nanotubes; graphene; endohedral metallofullerenes; peapods; carbon nanohorns and nanoonions; synthesis and analytical techniques. **B2:** Preparation techniques (Langmuir-Blodgett films, self-assembled monolayers, sublimation, spin-casting, spraying), self-assembly, structural and spectroscopic analytical techniques, heterostructures, phase diagrams. **B3:** Ionisation methods (EI, CI, FD, FI, SIMS, FAB, MALDI and ESI), ion formation mechanisms, analysers (ToF, sector field, quadrupole, ion trap, FT-ICR, orbitrap), tandem mass spectrometry, ion activation and fragmentation, thermochemical and analytical applications. **B4:** Symmetry of molecules, symmetry operations and point groups; symmetry of periodic systems; compact course to group theory; group theory and quantum mechanics; symmetry and spectroscopy: vibrational spectroscopies; tensor description of physical properties; band structures. **B5:** Surfaces of metals, oxides and ionic crystals;surface analytical techniques; bonding of molecules to surfaces: bonding mechanisms; Blyholder model; adsorbate interactions and superstructures; temperature programmed desorption/reaction; concepts and definitions in catalysis; microkinetics of catalystic processes; transport limitations; surface dynamics and surface kinetics; model catalysis. **B6:** Energy portfolio; electron transfer; Si solar cells; dye-sensitized solar cells; organic photovoltaics; multiple excition generation cells; photosynthesis; artificial photosynthesis **B7:** Self-assembly of surfactants; self-assembly of more complex amphiphilic molecules; interaction forces in colloidal systems; osmometry;	

		light scattering; form factor as key to particle shape; ; dynamic Light Scattering; fractionating Methods for Nanoparticle Analytics; combined Use of Characterization Methods; supramolecular nanoparticles by H-bridges and metal coordination; special Behaviour of polyelectrolytes; nanostructures with polyelectrolytes
6	**Educational goals and Learning outcome**	The students are able • to understand the advanced principles of experimental techniques in physical chemistry • to evaluate the application of experimental and/or theoretical techniques in modern material science/materials research • to plan and perform advanced lab experiments and/or lab project related to actual research topics in physical chemistry • to utilize selected preparation techniques for sample preparation • to apply and understand modern experimental methods for sample characterization • to interpret and to critically summarize their experimental results in written form (lab report, sometimes in paper-style format).
7	**Prerequisites *Voraussetzungen für die Teilnahme***	Admission to the M. Sc. program Molecular Science or Chemistry
8	**Intended stage in the degree course**	Mandatory elective module (Wahlpflichtmodul) or Elective Module (Wahlmodul) semester 1 - 3
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Science (as mandatory elective module) M. Sc. Chemistry (as elective module) *) *) no overlap with courses in Mandatory elective Module “Interface phenomena” or Mandatory Module allowed
10	**Assessment and examinations**	Portfolio: Depending on the choice of the module LAB (SL, AP) Lab course protocol(s) without marks + oral examination (45 min, 2 examiners)
11	**Calculation of the grade for the module**	100% from oral examination
12	**Frequency of offer**	Annually A: upon appointment with course lab supervisor or research lab supervisors B1- B5; B7: winter term, B6: summer term
13	**Workload**	450 hours (includes 240 hours private studies)
14	**Duration**	2 semesters
15	**Language**	English
16	**Preparatory reading / reading list**	Manuscripts for most lectures available online (check StudOn or lecturers’ web site)

1	**Module Name**	**MSM-ME4 Molecular Biology**	**15 CP**
2	**Courses**	Integrated course, combining lectures seminar and experimental work (in total: 15 SWS), consisting of: A1: Recombinant proteins A2: Techniques in molecular genetics A3: Immunochemistry A4: Structural biology A5: Plant molecular biology	
3	**Module Coordinator**	Prof. Dr. C. Koch; Prof, Yves Muller	
4	**Teaching Staff**	Dr. Ruth Stadler, Dr. Wilhelm Eisenbeiß, Prof. Dr. Lars Nitschke, Prof. Dr. Yves Muller; Dr. Benedikt Schmid; Prof. Christian Koch	
5	**Syllabus Outline**	**A1:** Recombinant DNA Polymerases are overproduced, purified, and biochemically characterized. Recombinant epitope-tagged eukaryotic transcription factors are purified by immunoprecipitation and detected with various antibodies. Lectures/seminars cover methods of recombinant protein expression, antibody detection, polymerase chain reaction, differences between pro- and eukaryotic gene expression. Modern chromatographic and analytical techniques used in protein purification. **A2:** Handling of plasmid DNA, ligation, bacterial transformation, purification of genomic DNA and RNA from animal cells, transfection of animal cell lines, GFP reporters, Fluorescence activated cell sorting, genetic fingerprinting. Lectures/seminars cover these techniques. **A3:** Investigation of high-molecular effective ingredients of anti-influenza vaccines and mistletoe plants. Isolation and analysis of personal IgG-fraction (SDSPAGE): Estimation of anti-influenza-antibodies (Dot-Blot, Western-Blot, ELISA). Purification of proteinaceous content from mistletoe herb and identification of mistletoe lectines (ELLA) **A4:** *Structural biology* (taught in english): Protein structure determination. Major steps in protein X-ray crystallography will be performed including protein crystallization, symmetry and analysis of electron density maps, phase determination using molecular replacement, refinement and validation of the structural model. The course starts with an UNIX/LINUX introduction, the operating system used by the computer programs. Lectures and seminars cover in detail all steps of the X-ray structure determination process and highlight the application spectrum of this technique. **A5:** *Plant molecular biology* (taught in english) Detection of reporter genes in transgenic tobacco, immunological localization of a protein in Plantago major, transient expression of a reporter gene in onion and tobacco, fluorescence microscopy and confocal laser scanning microscopy. Lectures and seminars cover methods of plant gene technology, agrobacterium-mediated plant transformation, detection of genes, RNA and proteins, importance of genetically engineered plants in science and industry.	
6	**Educational goals and Learning outcome**	The students are able • to understand the fundamentals of selected topics in molecular biology • to utilize the modern experimental techniques in molecular genetics • to determine protein structures using X-ray crystallography • to prepare and to characterize of different samples (depending on chosen lab course) using appropriate experimental techniques and methods • to interpret and to critically summarize experimental results in written form (lab report) • to judge and to discuss in oral form their research results in the field of drug discovery in comparison to recent publications • to work in smaller research teams (team ability).	

7	**Pre-requisites**	B.Sc. Molecular Science (Life Science track) or sufficient theoretical background in molecular biology
8	**Intended stage in the degree course**	Mandatory elective module (Wahlpflichtmodul) or Elective Module (Wahlmodul) semester 1 - 3
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Life Science
10	**Assessment and examinations**	Portfolio: LAB (SL, AP) Oral examination (45 min, 2 examiners)
11	**Calculation of the grade for the module**	100% from oral examination
12	**Frequency of offer**	Annually (winter term, taught between November and February)
13	**Workload**	450 hours (which includes 240 hours private studies)
14	**Duration**	1 semester
15	**Language**	A1.partly taught in German (30%), therefore only electable by students with beginners level German and advanced level English. A2: German A3: either English or German A4/A5: English
16	**Preparatory reading / reading list**	Watson Baker et al: “Molecular biology of the gene” (Pearson International).

1	**Module Name**	**MSM-ME5 Medicinal Chemistry (Option A or B)**	**15 CP**
2	**Courses**	**Option A: Pharmaceutical Chemistry** Lectures: A1:Pharmacopoeia-based analysis of bioactive compounds (1L + 1L) A2: Pharmaceutical/Medicinal Chemistry 3L + 3L) Lab course: A3: Pharmacopoeia-based analysis of bioactive compounds (7Lab) **Option B: Biopharmacy** Lectures & Seminars: B1: Biopharmazie Seminar (2S) B2: Biopharmazie VL (2S) B3: Gefriertrocknung pharmazeutischer Produkte Seminar (2S) B4: Bioanalytik Seminar(2 S) Lab courses: B5:Bioanalytics and instrumental analytics (5Lab) B6: Bioassays (3Lab)	
3	**Module Coordinator**	Prof. Dr. M. Pischetsrieder	
4	**Teaching Staff**	A1, A2: Prof. Dr. Eichler, Prof. Dr. Gmeiner A3: Prof. Eichler (coordinator) B1: Prof. Dr. Lee B2: Prof. Dr. Lee B3: PD Dr. H. Gieseler B4: Prof. Dr. Pischetsrieder B5: Prof. Dr. Pischetsrieder B6: Prof. Dr. Gmeiner, Dr. N. Tschammer (coordinator: Dr. Hübner)	
5	**Syllabus Outline**	Option A: **A1:** General, as well as substance-specific methods for the qualitative and quantitative analysis (identity, purity, concentration) of drug substances according to the European Pharmacopeia; assessment of physico-chemical properties and reactivities of drug substances, based on their structures; evaluation of the informational value (selectivity, specificity) of individual analysis methods/reactions; special focus: color reactions. **A2:** Theoretical knowledge and understanding for the mechanism of action, chemical synthesis, biotransformation, physikochemical properties and SAR studies of the most important drugs and bioactive compound families including: Agents affecting the nervous system, agents with cardiovascular effects, antiallergics, analgesics, antidiabetics, antibiotics, chemotherapeutics and vitamins. **A3:** lab course on the pharmaceutical analysis of drugs; determination of identity, purity and quantification **Option B:** **B2:** Pharmacokinetics: distribution of drug molecules within the body after drug product application. **B3:** Stability, formulation and manufacture of drug products from recombinant human protein drugs. **B4:** Theoretical knowledge on technology and application of advanced modern methods in instrumental and bio-analysis; acquainting students with current issues in the fields of instrumental and bioanalysis **LAB courses:** **B5:** Analytical practice courses to learn the most important basic techniques in the field of instrumental and bioanalysis **B6:** Practical courses to learn the most important basic approaches and techniques in the field of bioassays (e.g. determination of the inhibition of enzymatic activity, receptor binding assays and analysis of signal transduction of G-protein coupled receptors)	

6	**Educational goals and Learning outcome**	The students • gain insight into the action of new drug products in the medicinal/pharmaceutical area • acquire expertise for the theoretical evaluation and practical application of the most important techniques for the instrumental and bioanalysis of drugs • are able to reflect crucial theories of the specialty in order to challenge problems in analytical practice.
7	**Prerequisites**	Admission to the M. Sc. program Molecular Science or Chemistry
8	**Intended stage in the degree course**	Mandatory elective module (Wahlpflichtmodul) or Elective module (Wahlmodul)
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Life Science
10	**Assessment and examinations**	Portfolio: LAB (SL, AP) Lab course protocol(s) without marks, presentation, oral examination (45 min, 2 examiners)
11	**Calculation of the grade for the module**	100% from oral examination
12	**Frequency of offer**	Annually A3: winter term A1/A2: winter & summer term B1: winter term or summer term, B2: winter term & summer term, B3: winter term & summer term. B4: winter term & summer term B5: semester break between winter and summer term B6: summer term
13	**Workload**	450 hours (including 240 hours private study)
14	**Duration**	2 semesters
15	**Language**	English (A3, B6); German (A1, A2, B1, B2, B3, B4, B5)
16	**Preparatory reading / reading list**	Online scripts available

1	**Module Name**	**MSM-ME6 Chemistry of Life**	**15 CP**
2	**Courses**	**A.** Chemistry of Biomolecules and Cellular Functions (2 SWS V) **B.** Cell Signaling and chemistry of oxidative stress (2 SWS V) **C.** Seminar: Experimental Techniques and Selected Topics in Chemical Biology of Diseases (1 S) **D**. Practical session (10 Lab)	
3	**Module Coordinator**	Prof. Dr. I. Ivanovic-Burmazovic	
4	**Teaching Staff**	**A**. Prof. A. Mokhir, Dr. M. Filipovic **B**. Prof. I. Ivanovic-Burmazovic, Dr. M. Filipovic, Prof. M. Herrmann **C**. PD. M. Fischer, Dr. M. Filipovic **D**. Prof. A. Mokhir, Dr. M. Filipovic, Prof. I. Ivanovic-Burmazovic, PD. M. Fischer	
5	**Syllabus Outline**	**A.** -Relation between the 3D protein structure and their function, including discussion of state-of-the-art methodology -Biochemistry of biological membranes (chemistry of carbohydrates, lipids an protein channels) -Chemical biology of nucleic acids as therapeutic targets -Protein-nucleic acid interactions -Cell as self-sustainable and bio-functional confined space -Nucleosides and Nucleotides -Chemical and biological synthesis of nucleic acids -DNA and RNA structure -Nucleic acids in biotechnology -Spectroscopic and structural methods applied in studies of nucleic acids -Nucleic acids and their analogues as drugs **B. -**Bioinorganic chemistry of electron transfer **-**Thermodynamics and kinetics of mitochondrial processes **-**Biochemistry of free radical generation and removal -Monitoring oxidative stress in living systems -Interplay between oxidative stress and cell signaling pathways: Inflammation, Neuropathie and Cancer as model systems -Redox drugs **C.** Seminar: Preparation for practical session with an accent on the methodological approach and medical aspects **D**. **d1:** Structure and function of proteins: denaturation/renaturation, protein-ligand interactions (UV-Vis, fluorescence and EPR spectroscopy, amperometric analysis of small-molecule interactions) **d2:** Kinetics of SOD and Catalase activity of natural enzymes and their synthetic mimics (direct stopped-flow methods vs. indirect assays) **d3:** Cell preparation for fluorescence microscopy (staining of cell compartments and detection of oxidative stress) **d4:** Protein purification and analysis (cell extract preparation, 2D-electrophoresis of total cell extract, trypsin digestion, HPLC separation and ESI-MS-detection) **d5:** Synthesis of a representative nucleic acid analogue; its identification (MALDI-TOF MS), purification (HPLC), quantification (UV-visible spectroscopy), study of binding to a target nucleic acid (fluorescence spectroscopy, melting profile measurement). **d6:** As a DEMO-Experiment: testing inhibitors in cellular cultures, monitoring inhibition by using flow cytometry and RT PCR.	
6	**Educational goals and Learning outcome**	The main goal is to provide students with the up-to-date practical and operative know-how suitable for future scientific and/or applied work in research institutes, pharmaceutical/food industry, medical care laboratories, bio-technological, bio-analytical and environmental branches, accompanied by advanced theoretical background and overview of emerging trends in life sciences (chemistry, biology and medicine). Rather than traditionally used phenomenological ap-	

		proach the courses are based on viewing living systems through the lens of basic chemical principles. The modern aspects of this module prepare students to work in interdisciplinary environment and participate in national and international development of forefront fields such as translational medicine.
7	**Prerequisites**	B.Sc. in Chemistry / B.Sc. Molecular Science (or equivalent molecule/synthesis-based studies)
8	**Intended stage in the degree course**	Mandatory elective module (Wahlpflichtmodul) or Elective module (Wahlmodul)
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular (Life) Science / M.Sc. Chemistry
10	**Assessment and examinations**	Lab course protocol(s) without marks + oral examination (45 min) 2 Examiners
11	**Calculation of the grade for the module**	100% from oral examination
12	**Frequency of offer**	Annually, starting WS; the module can only be taken as a whole
13	**Workload**	450 hours (including 225 hours private study)
14	**Duration**	2 semesters
15	**Language**	English (selected courses can be taught in German)
16	**Preparatory reading / reading list**	Selected chapters from: -Voet & Voet, Biochemistry, Wiley & Sons; -Barry Halliwell & John M. C. Gutteridge, Free Radicals in Biology and medicine, Oxford -I. M. Rosenberg, Protein Analysis and Purification, Birkhäuser -Bertini, Gray, Stiefe, Valentine, Biological Inorganic Chemistry, Structure & Reactivity, University Science Books - F.Marks, U. Klingmüller, K. Müller-Decker, Cellular Signal Processing: An Introduction to the Molecular Mechanisms of Signal Transduction, Taylor & Francis

Elective Module

1	**Module Name**	**Elective Module**	**15 CP**
2	**Courses**	Module of the student's choice and approval by the representative of the study course or the students' dean. The chair offering the module and the courses has to appoint a responsible person, who will be one of the two examiners and ascertains the handling of the module of approximately 15 semester hours. **Please note:** 2/3 of the courses of the elective module must be topically related to the study program, 5 ECTS from soft skills or key qualifications will be accepted Another Mandatory elective from M.Sc. Molecular Science or M.Sc. Chemistry may be chosen, however, there must be no overlap with courses from the Mandatory module or Mandatory elective module	
3	**Module Coordinator**	Students' Dean or respective module coordinator (for structured modules)	
4	**Teaching Staff**	Diverse, see respective Mandatory elective modules or UnivIS	
5	**Syllabus Outline**	Recommended choices (based on mandatory elective modules): **For Molecular Life Science: (5 L, 7 Lab, 3 S) or (8 L, 0 Lab, 1 S#)** Molecular Biology or Medicinal Chemistry (Option A) or Medicinal Chemistry (Option B) Molecular Synthesis Bioinorganic Chemistry (from M.Sc. Chemistry **For Molecular Nanoscience: (5 L, 7 Lab, 3 S) or (8 L, 0 Lab, 1 S#)** Molecular synthesis Theory Physical Chemistry (or parts of the respective modules) **#= Elective module without a LAB Course**	
6	**Educational goals and Learning outcome**	Extension of the knowledge in special research focused topic Soft skills	
7	**Prerequisites**	Admission to the M. Sc. program Molecular Science or Chemistry	
8	**Intended stage in the degree course**	Elective module (Wahlmodul), semester 1 - 3	
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Lifescience/M.Sc. Molecular Nanoscience	
10	**Assessment and examinations**	Portfolio. Depending on the choice of the module	
11	**Calculation of the grade for the module**	Portfolio. Depending on the choice of the module	
12	**Frequency of offer**	Annually (for details, see description of the Mandatory elective modules)	
13	**Workload**	450 hours (including 240 hours private study)	

14	**Duration**	2 semesters
15	**Language**	English
16	**Preparatory reading / reading list**	Depending on chosen modules/lectures (contact lecturer or lecturers web site or UnivIS)

<table>
<tr><td>1</td><td>Module Name</td><td>MSM-SM Scientific Methods</td><td>10 CP</td></tr>
<tr><td>2</td><td>Courses</td><td>A: Seminar Scientific English (2 S), scientific writing (2 S) (5 ECTS)

B: Scientific data, literature and information management 2 S (5 ECTS)</td><td></td></tr>
<tr><td>3</td><td>Module Coordinator</td><td>Students' Dean</td><td></td></tr>
<tr><td>4</td><td>Teaching Staff</td><td colspan="2">All teachers in the Department Chemistry and Pharmacy as well as Biology, Sprachenzentrum</td></tr>
<tr><td>5</td><td>Syllabus Outline</td><td colspan="2">In this module the students should become familiar with important general methodologies in science: project planning, scientific writing in English, information retrieval and management.</td></tr>
<tr><td>6</td><td>Educational goals and Learning outcome</td><td colspan="2">The students are able
• present conference presentations in English
• write and receive direct feedback on texts relating to various aspects of molecular science
• to interact in the class in English
• understand modern aspects of molecular sciences and chemistry and can express these aspects both in written and spoken English
• to retrieve relevant literature from available databases (e.g. Web of Science, Scifinder, Reaxys, Scopus)
• to organize relevant information using software tools such as literature management systems (Endnote, Mendeley, Citavi)
• to condense and evaluate the information
to write a state-of-the-art scientific literature survey

Alternative acceptable English courses

<table>
<tr><th></th><th>allgemein</th><th>fachbezogen</th></tr>
<tr><td>B2</td><td>▸ Level 2: Focus on Academic Speaking
▸ Level 2: Focus on Academic Writing
▸ Level 2: Grammar and Vocabulary
▸ Level 2: Pronunciation Course</td><td>▸ English for Natural Scientists</td></tr>
<tr><td>C1</td><td>▸ Level 3: Focus on Academic Speaking
▸ Level 3: Focus on Academic Writing
▸ Level 3: Focus on Reading and Vocabulary
▸ Level 4: Advanced Academic English
▸ Level 4: Advanced Oral Expression in an Academic Context</td><td>▸ Level 3: English for Natural Scientists
▸ Level 3: Presenting Scientific Papers for Natural Scientists, M. Sc.
▸ Level 3: Writing Scientific Papers for Natural Scientists, M. Sc.
▸ Level 4: Writing and Presenting Scientific Papers</td></tr>
</table>

(Level 1 will not be accepted)</td></tr>
<tr><td>7</td><td>Prerequisites</td><td colspan="2">Admission to the M. Sc. program Molecular Science or Chemistry</td></tr>
</table>

8	**Intended stage in the degree course**	Module accompanying the Mandatory module for Molecular Science (Pflichtmodul)
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Science
10	**Assessment and examinations**	One written (10-15 pages) literature survey about a scientific topic
11	**Calculation of the grade for the module**	No grade
12	**Frequency of offer**	Continually 3rd semester
13	**Workload**	300 hours (includes 210 hours private studies)
14	**Duration**	1 semester
15	**Language**	English
16	**Preparatory reading / reading list**	Not applicable

1	**Module Name**	**MSM-CA Current Aspects in Molecular Science**	**10 CP**
2	**Courses**	Scientific presentation, workshop	
3	**Module Coordinator**	Students' Dean	
4	**Teaching Staff**	All teachers in the Department Chemistry and Pharmacy as well as Biology	
5	**Syllabus Outline**	The students have to attend **10** lectures related to modern molecular sciences. The lectures can be out of any lecture series of the Departments Chemistry/Pharmacy or Biology. Alternatively lectures from conferences/workshops related to the study program can be used. Not suitable are ceremonial addresses (e.g. inaugural lectures, "Antrittsvorlesungen"), presentations given as part of a Ph.D. defense, or popular scientific talks. Additionally, scientific results have to be presented as a poster.	
6	**Educational goals and Learning outcome**	The students are able • understand modern aspects of molecular sciences and chemistry • understand and document a scientific presentation • communicate the content of a dense scientific presentation to peers communicate scientific information in form of a poster	
7	**Prerequisites**	Admission to the M. Sc. program Molecular Science or Chemistry	
8	**Intended stage in the degree course**	Module accompanying the Master Thesis	
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Science	
10	**Assessment and examinations**	Attendance of 10 scientific lectures, one poster presentation in a workshop	
11	**Calculation of the grade for the module**	No grade	
12	**Frequency of offer**	Continually	
13	**Workload**	300 hours (includes 270 hours private studies)	
14	**Duration**	1 semester 3rd semester	
15	**Language**	English	
16	**Preparatory reading / reading list**	Not applicable	

1	**Module Name**	**MSM-REP Repetition and Rehearsal**	**10 CP**
2	**Courses**	**Seminar Exam preparation 2 S**	
3	**Module Coordinator**	Students‘ Dean	
4	**Teaching Staff**	All teachers in the Department Chemistry and Pharmacy as well as Biology	
5	**Syllabus Outline**	Interdisciplinary problem solving seminar covering all aspects of modern molecular sciences with focus on the knowledge and competencies required for the oral exams; simulation of test situation	
6	**Educational goals and Learning outcome**	The students are able • understand modern aspects of molecular sciences and chemistry • solve problems in molecular sciences cope with test situations and heavy work load	
7	**Prerequisites**	Admission to the M. Sc. program Molecular Science or Chemistry	
8	**Intended stage in the degree course**	Module prepares for oral exams	
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Science	
10	**Assessment and examinations**	Not applicable	
11	**Calculation of the grade for the module**	No grade	
12	**Frequency of offer**	Continually	
13	**Workload**	300 hours (includes 270 hours private studies)	
14	**Duration**	1 semester 3rd semester	
15	**Language**	English	
16	**Preparatory reading / reading list**	Not applicable	

Master Thesis

1	**Module Name**	**Master thesis**	**30 CP**
2	**Courses**	Master thesis (includes the research seminars of the respective research group)	
3	**Module Coordinator**	Board of Examination	
4	**Teaching Staff**	Supervisor of the Master thesis must be professor, who is involved in the M.Sc. Molecular Science course studies	
5	**Syllabus Outline**	Written elaboration in form of a scientific manuscript. It describes the scientific findings as well as the way leading to these findings. It contains justifications for decisions regarding chosen methods for the thesis and discarded alternatives. The student's own substantial contribution to the achieved results has to be evident. In addition, the student presents his work in a seminar, in which the scientific quality and the scientific independence of his achievements are evaluated.	
6	**Educational goals and Learning outcome**	Students - demonstrates his ability to perform independent scientific work focusing on an adequately challenging research topic. - rank their own research results in the context of current literature and research papers in the field and record their results in appropriate scientific writing and documentation style. - give oral and written presentations of the results and acquired knowledge in an appropriate scientific style in English language	
7	**Prerequisites**	Admission to the M. Sc. program Molecular Science, Passed oral exams from Mandatory Module, Mandatory elective Module and Elective Module, Rep Module	
8	**Intended stage in the degree course**	Final Master Thesis	
9	**Courses of study for which the module is acceptable**	M.Sc. Molecular Life/Nano Science	
10	**Assessment and examinations**	Written thesis (usually between 60 to 80 pages): TH: 3 hard copies in bound form + electronic version, referee report, 2 experts	
11	**Calculation of the grade for the module**	Averaged grade of the two reports	
12	**Frequency of offer**	permanent	
13	**Workload**	900 hours (includes 50 contact hours)	
14	**Duration**	1 semester	
15	**Language**	English	
16	**Preparatory reading / reading list**	Actual project related literature (according to topic)	