# Module Handbook
# for the
# International Master's Programme
# *Biofabrication*
# at the University of Bayreuth
# from 05 July 2016,

# updated version 4. Amendment of the Study Regulations from 01. August 2019

Great care has been taken in the preparation of this module handbook. Due to the extent of the material however, errors cannot be ruled out completely. Therefore, no guarantee is given for the correctness of the information. The official examination and study regulations, in their current version, are binding.

## Preliminary remarks

The Faculty of Engineering Science at the University of Bayreuth has produced a module handbook which describes the modules that make up the international master's programme *Biofabrication*.

Herein are listed: Content and the qualification objective, prerequisites, possible uses in the course, the frequency at which the module is offered, the period of time within which the module can be completed, the courses that make up the module as well as the credits to be acquired as a measure of the workload and a description of the type of assessment components required for the award of credits.

### Abbreviations:

| | | | |
|---|---|---|---|
| CP: | Credit Points | SWS: | Weekly hours per semester |
| P: | Practical course/Internship | nP: | Practical training of n weekly hours per |
| S: | Seminar | nS: | Seminar of n weekly hours per semester |
| T: | Tutorial | nT: | Tutorial with n weekly hours per semester |
| V: | Lecture | nV: | Lecture of n weekly hours per semester |

## Outline of the study programme

The international master's programme *Biofabrication* has a modular structure. The study programme consists of the following sections:

1. General Part
   a) Materials and Natural Sciences
   b) Engineering Science
   c) Transferable Skills
2. Specialization
3. Master's Thesis

# Contents

## Compulsary Modules



## Core elective modules

# Module AM

| | | |
|---|---|---|
| 1 | Module name: | **Advanced module** |
| 2 | Subject area / | Subject-related skills |
| | Responsible for the module: | Participating Profs. in the study programme (University of Bayreuth, and national partner universities / institutions according to the list) |
| 3 | Content and qualification objective: | |
| | a) Content: | The educational content relates to the current research projects of the respective chosen research group. The module includes experimental work, literature work, participation in the working group seminars with presentation and preparation of a report. |
| | b) Qualification objective: | The students will gain an insight into the research practice of various groups involved. In addition, they will acquire experimental skills through laboratory work under supervision, and teamwork will be practiced and presentation techniques trained. |
| 4 | Prerequisites: | The successful completion of the general subject-related modules is recommended. |
| 5 | Possible inclusion in curriculum: | In the third or fourth semester |
| 6 | Frequency: | at any time |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | Organiser | SWS | CP |
|---|---|---|---|---|
| 1 | AM1 | (Participating chairs/profs in the degree programme) | x | 8 |
| 2 | AM2 | (Participating chairs/profs in the degree programme) | x | 8 |
| 3 | AM3 | (Participating chairs/profs in the degree programme) | x | 8 |
| | | Total | x | 24 |

| | | |
|---|---|---|
| 9 | Module examination: | Portfolio examination: an oral presentation (30 min, weighting 0.3) and a written report (weighting 0.7) per sub-module |
| 10 | Student workload: | Module AM1 240 h, AM2 240 h, AM3 240 h<br><br>**Module AM total: 720 hours** |

# Module BF

| | | |
|---|---|---|
| 1 | Module name: | **Biofabrication** |
| 2 | Subject area / | Materials Science |
| | Responsible for the module: | Professorship of Biofabrication |
| 3 | Content and qualification objective: | |
| | a) Content: | Definitions: Scaffolding / support materials, matrices, generative manufacturing processes; Bio-printing / cell printing, Biofabrication; Medical / ATMP / regulatory basis; Introduction to anatomical basic knowledge; Materials / polymers for Biofabrication; Introduction to rheology; Melting stratification, creation of G-codes and STL files; constructing objects with Solid Works software; Dispenser printing; Inorganic powder printing, stereolithography and two-photon polymerization; Melt Electrospinning writing; Applications of Biofabrication |
| | b) Qualification objective: | Basic understanding of the various objectives of Biofabrication and knowledge as well as ability to assess restrictions of production; Design and manufacture of 3D objects by using appropriate software and digital signals based on anatomical- and print-dependant resolution. Understanding of the different possibilities of 3D printing, as well as mechanical and technical process details. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: General Process Engineering; Composition and Properties of Polymers |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | BF | Biofabrication | 2L + 2T | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 hpreparation/follow-up work = 45 h;<br>Weekly 2 h practice plus 2 h preparation/follow-up work = 60 h;<br>Exemamination preparation = 45 h<br><br>**Module BF total: 150 hours** |

# Module BMA

| | | |
|---|---|---|
| 1 | Module name: | **Biomaterials** |
| 2 | Subject area / Responsible for the module: | Engineering Science / Materials Science<br>Chair of Biomaterials |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br><br><br>b) Qualification objective: | <br>Materials science across different material classes, natural macromolecules, biopolymers and composite materials, hybrid materials; Biomaterials, biomineralization, deepening of biochemical / biophysical analytical methods; Design principles of nature as a template for biomimetic technical applications; Applications in nanotechnology, pharmacology/medical technology, material science and industry.<br><br>Consolidation of knowledge of materials science across material classes, natural macromolecules and biopolymers and their assembly; acquisition of a comprehensive overview of structural and biophysical analysis of natural macromolecules; acquisition of systematic methodological skills for analysing and processing, as well as communication of interdisciplinary scientific aspects in theory and practice; acquisition of decision-making competence regarding possible technical applications. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: Biochemistry for Engineers; Biology for Engineers |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | BMA | Biomaterials | 2L + 2T | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 h;<br>Weekly 2 hours seminar plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 45 h<br><br>**Module BMA total: 150 hours** |

# Module CAE

| | | |
|---|---|---|
| 1 | Module name: | **Computer Aided Engineering** |
| 2 | Subject area /<br>Responsible for the module: | Engineering Science<br>Chair of Design and CAD |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br>b) Qualification objective: | <br>CAE1: mastery of modern calculation methods and their application to constructive tasks; knowledge of associated software. Ability to design independently using CAD.<br>CAE2: theory and application of finite element method to static problems with a focus on the constructive point of view and modelling.<br><br>CAE1: ability to create CAD models and generate design proposals using optimization algorithms.<br>CAE2: mastery of modern methods of calculation of statics and their application to constructive tasks; knowledge of associated software |
| 4 | Prerequisites:<br>beneficial. | Basic technical understanding; further knowledge of numerics is |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | CAE1 | Optimization | 2L | 3 |
| 2 | CAE2 | FE Seminar | 2T | 2 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | Portfolio examination: a written examination (duration 90 minutes, weighting 60%) and a written composition (weighting 40%) |
| 10 | Student workload: | Weekly 2 h lecture plus 2 h preparation/follow-up work = 60 h;<br>Weekly 2 h seminars plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 30 h.<br><br>**Module CAE total: 150 hours** |

# Module CB

| | | |
|---|---|---|
| 1 | Module name: | **Cell Biology** |
| 2 | Subject area /<br>Responsible for the module: | Natural Sciences<br>Chair of Biomaterials |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br><br><br><br>b) Qualification objective: | <br>Cell structure and function, cellular metabolism, genetics. Basic chemical composition of living matter. Structural characteristics of prokaryotic and eukaryotic cells. Comparison of plant and animal cells, Mechanics of membrane transport. Cell membranes and membranous organelles, Basic concepts of bioenergetics, photo-synthesis, and cellular respiration. Mechanics of cellular reproduction. Nucleic acids and basic concepts of protein synthesis and gene regulation.<br><br>The focus is the study of the structure and function of the cell. Students will learn about Eukaryotic cell biology and topics such as membrane structure and composition, transport, and trafficking; the cytoskeleton and cell movement; the breakdown of macromolecules and generation of energy; and the integration of cells into tissues. Also covered are important cellular processes such as cell cycle regulation, signal transduction, apoptosis (programmed cell death), and cancer cell biology. Ability to relate defects in these various cellular processes to human diseases to help gain a better understanding for what happens when cells don't work as they should. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: none |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | CB | Fundamentals of Cell Biology | 2L + 2P | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 h;<br>Weekly 2 h practical training plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 45 h.<br><br>**Module CB total: 150 hours** |

# Module CPC

| | | |
|---|---|---|
| 1 | Module name: | **Chemistry and Polymer Chemistry** |
| 2 | Subject area / | Engineering Science |
| | Responsible for the module: | Professorschip of Biofabrication |
| 3 | Content and qualification objective: | |
| | a) Content: | Fundamentals of organic chemistry, synthesis and chemical properties of the most important classes of organic compunds (alkanes, alkohols, halogenides, alkenes, alkines, arenes, aldehydes, ketones, carbon acids, esters, amines, phenoles). Main types of organic reactions (nucleophile substitution) , electrophile addition), fundamentals of polymer chemistry. |
| | b) Qualification objective: | The students should get a basic understanding of the fundamental synthetic organic chemistry as well as of synthesis and chemical modification of polymers, compentence of decission-making of planned synthesis of polymers with targeted properties. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: none |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | CPC | Introduction in Organic and Polymer Chemistry | 2L + 2T | 5 |
| | | Total | 4 | 5 |

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|---|---|---|
| 9 | Module examination: | A written examination (60 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 h;<br>Weekly 2 h tutorial plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 45 h.<br><br>**Module CPC total: 150 hours** |

# Module FTE

| | | |
|---|---|---|
| 1 | Module name: | **Fundamentals of Tissue Engineering and Quality Management** |
| 2 | Subject area /<br>Responsible for the module: | Natural Sciences / Bioprocess technology<br>Chair of Process Biotechnology |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br>b) Qualification objective: | <br>Tissue engineering of complex constructs: supply, hypoxia, nutrient diffusion, extracellular matrix, supply with nerves and blood vessels. Performance of risk analysis in accordance with ISO 17025:2005, Biological evaluation of medical devices according to DIN EN ISO 10993.<br><br>The students will have knowledge of tissue engineering and quality management. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: none |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | FTE1 | Fundamentals in Tissue Engineering | 2L + 1P | 3 |
| 2 | FTE2 | Quality Management | 1L | 2 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (90 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 3 h lecture plus 3 h preparation/follow-up work = 90 h;<br>Weekly 1 h practical training plus 1 h preparation/follow-up work = 30 h;<br>Examination preparation = 30 h<br><br>**Module FTE total: 150 hours** |

# Module IAM

| | | |
|---|---|---|
| 1 | Module name: | **International Advanced Module** |
| 2 | Subject area / Responsible for the module: | Subject-related skills<br>Participating groups of international partner universities / institutions according to the list |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br>b) Qualification objective: | <br>The educational content relates to the current research projects of the respective chosen research group. The module includes experimental work, literature work, participation in the working group seminars with presentation and preparation of a report.<br><br>The students will gain an insight into the research practice of various groups involved. In addition, they will acquire experimental skills through laboratory work under supervision; teamwork will be practiced and presentation techniques trained. |
| 4 | Prerequisites: | The successful completion of the general professional module is recommended. |
| 5 | Possible inclusion in curriculum: | In the third or fourth semester |
| 6 | Frequency: | at any time |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | Organiser | SWS | CP |
|---|---|---|---|---|
| 1 | IAM | (Participating international partners see list) | x | 24 |
| | | Total | x | 24 |

| | | |
|---|---|---|
| 9 | Module examination: | Portfolio examination: an oral presentation (30 minutes, weighting 30%) and a written report (70%). |
| 10 | Student workload: | **Module IAM: 720 hours** |

# KES core elective module area

| | | |
|---|---|---|
| 1 | Module name: | **Engineering Science: Subject-related skills** |
| 2 | Subject area/<br>Responsible for the module: | Engineering Science<br>Participating groups in the study programme |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br>b) Qualification objective: | <br>Students choose from individual modules from a regularly updated list. The modules cover specialized subjects of engineering science relevant to the study programme.<br><br>Developing individual skills; Acquiring vocationally relevant professional skills that were not yet adequately developed; see individual descriptions of selectable modules (elective module list for the area of Engineering Science). |
| 4 | Prerequisites: | See individual announcements of the relevant modules |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | KES | (see Engineering Science catalogue of core elective modules) | x | 5 |
| | | Total | x | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | according to the modules selected (see Engineering Science catalogue of core elective modules) |
| 10 | Student workload: | according to the modules selected (see Engineering Science catalogue of core elective modules)<br><br>**KES module total: 150 hours** |

# KMNS core elective module area

| | | |
|---|---|---|
| 1 | Module name: | **Materials and Natural Sciences: Subject-related skills** |
| 2 | Subject area /<br>Responsible for the module: | Materials and Natural Sciences<br>Participating chairs in the programme of study |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br>b) Qualification objective: | <br>Students choose from individual modules from a regularly updated list. The modules cover specialized subjects from Material and Biomedical Science relevant to the programme of study.<br><br>Developing individual subject-related skills; Acquiring vocationally relevant professional skills that were not yet adequately developed; see individual descriptions of selectable modules (elective module list for the area of Material and Biomedical Sciences). |
| 4 | Prerequisites: | See individual announcements of the relevant modules |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | KMNS | (see Material and Natural Science catalogue of core elective modules) | x | 5 |
| | | Total | x | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | according to the modules selected (see Materials and Natural Sciences catalogue of core elective modules) |
| 10 | Student workload: | according to the modules selected (see Materials and Natural Sciences catalogue of core elective modules)<br><br>**KMNS module total: 150 hours** |

# MMT module

| | | |
|---|---|---|
| 1 | Module name: | **Management Training and Entrepreneurship** |
| 2 | Subject area/<br>Responsible for the module: | Transferable skills<br>Chair of Biomaterials |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br>b) Qualification objective: | <br>Students choose from individual modules from a regularly updated list. The modules cover topics to promote personal profiling. These include courses in "soft skills", management of projects, intellectual property and patents, as well as entrepreneurship, business models and company start-up.<br><br>cross-disciplinary expertise; acquiring vocationally relevant transferable skills that were not yet adequately developed; see individual descriptions of selectable modules (elective module list for the area of Management Training). |
| 4 | Prerequisites:<br>modules | See individual announcements of the relevant |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 2 semesters |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | MMT1 | (see Management Training selection catalogue ) | x | 3 |
| 2 | MMT2 | (see Management Training selection catalogue ) | x | 2 |
| 3 | MMT3 | Entrepreneurship | x | 1 |
| | | Total | x | 6 |

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|---|---|---|
| 9 | Module examination: | according to the modules selected (see Management Training selection catalogue ), MMT3 is compulsory |
| 10 | Student workload: | according to the modules selected (see Management Training selection catalogue ),<br><br>**Module MMT total: 180 hours** |

# Module MT

| | | |
|---|---|---|
| 1 | Module name: | **Master's Thesis** |
| 2 | Subject area / Responsible for the module: | Participating chairs in the programme of study |
| 3 | Content and qualification objective:<br>a) Content:<br><br>b) Qualification objective: | <br>Written thesis on a current engineering topic which is provided by a professor or *Privatdozent* of the participating faculties of the University of Bayreuth.<br><br>Ability to independently process a research-related engineering problem; practice written and oral presentation and communication skills. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) evidence of examination totalling at least 55 CP |
| 5 | Possible inclusion in curriculum: | In the third or fourth semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester (completed within 6 months) |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | MT | Master's Thesis | – | 30 |
| | | Total | | 30 |

| | | |
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| 9 | Module examination: | Graded written thesis (weighting 0.75) and graded oral presentation (30 min., weighting 0.25). |
| 10 | Student workload: | **Module MT total: 900 hours** |

# Module PPM

| | | |
|---|---|---|
| 1 | Module name: | **Processing of Polymeric Materials** |
| 2 | Subject area /<br>Responsible for the module: | Engineering Science / Materials Science<br>Professorship of Biopolymer Processing |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br><br><br><br><br>b) Qualification objective: | <br>Processing methods of natural and synthetic polymers from the aspects of materials and engineering science, introduction to the theoretical basis for describing the deformation and flow behaviour of polymeric materials: fluid mechanics, elasticity theory and plasticity theory; flow properties of liquids (melts, solutions) and their significance in polymer processing; deformation and fracture mechanics of polymers taking into account structural features; analytical methods for measuring rheological properties; implementation of competencies acquired through experimental laboratory work.<br><br>Acquisition of competence in the field of characterization and processing of polymeric fluids (melts, solutions); influence of processing methods on the solid mechanics of polymeric materials; Decision-making competence in the choice and application of analytical methods for the characterization of polymeric liquids and solids, as well in the interpretation of the measurement data . |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: general process engineering, composition and properties of polymers |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | PPM1 | Aspects in Processing of Polymeric Materials | 2L + 1T | 4 |
| 2 | PPM2 | Processing of Polymeric Materials Practical Course | 1P | 1 |
| | | Total | | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 min, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 h;<br>Weekly 1 h tutorial plus 1 h preparation/follow-up work = 30 h;<br>Weekly 1 h practical training plus 1 h preparation/follow-up work = 30 h;<br>Examination preparation = 45 h<br><br>**Module FTE total: 150 hours** |

# Module SA

| | | |
|---|---|---|
| 1 | Module name: | **Summer Academy** |
| 2 | Subject area / Responsible for the module: | Materials and Natural Sciences / Engineering Science<br>Chair of Biomaterials |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br><br><br>b) Qualification objective: | <br>The course content involves the latest methods and concepts in biofabrication research (fundamental scientific questions, terminology, methods and laboratory equipment). Lectures will be given by lecturers from Germany and abroad and instructors of the Biofabrication programme. Thus, the students receive a thorough overview of different research focuses (incl. international partners) and get to know the excellent instrumental equipment at UBT and its infrastructure.<br><br>The students will gain an insight into biofabrication in general and the research practice of various groups involved in particular. |
| 4 | Prerequisites: | advanced study skills |
| 5 | Possible inclusion in curriculum: | between the first and second or second and third semesters |
| 6 | Frequency: | winter semester |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | Organiser | SWS | CP |
|---|---|---|---|---|
| 1 | SA | Summer Academy | x | 5 |
| | | Total | x | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 min) |
| 10 | Student workload: | **Module SA: 150 hours** |

# Module SAB

| | | |
|---|---|---|
| 1 | Module name: | **Self-Assembling Biopolymers** |
| 2 | Subject area / Responsible for the module: | Natural Sciences<br>Chair of Biomaterials |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br>b) Qualification objective: | <br>Natural macromolecules, biopolymers and composite materials, assembly mechanisms and thermodynamics, hybrid materials; Consolidation of biochemical / biophysical analytical methods.<br><br>Consolidation of the knowledge of natural macromolecules and biopolymers and their assembly in micro, macro and superstructures; Acquisition of a comprehensive overview of structural and biophysical analysis of natural macromolecules; Acquisition of systematic methodological competence in analysis and processing, as well as communication of interdisciplinary science aspects in theory and practice. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: Biochemistry for Engineers |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | SAB | Self-Assembling Biopolymers | 2L + 2T | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 hours;<br>Weekly 2 h tutorials plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 45 h<br><br>**Module SAB total: 150 hours** |

# Module SF

| | | |
|---|---|---|
| 1 | Module name: | **Scientific Working** |
| 2 | Subject area /<br>Responsible for the module: | Transferable skills<br>Chair of Biomaterials |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br><br>b) Qualification objective: | <br>Introduction to the basics of scientific work; Design of experiments as well as data documentation and data quality control; Conveying the rules of good scientific practice. Introduction to the handling of scientific literature; Search, review, and critical examination of publications; Conveying the rules for good publishing. Presentation and discussion of case studies in small groups.<br><br>Knowledge of the rules of good scientific practice; systematic competence in the appraising scientific misconduct; Scientific discussion skills. |
| 4 | Prerequisites: | advanced study skills |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 2 semesters |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | SF1 | Ethics in Science | 1L | 1 |
| 2 | SF2 | Reception of Scientific Literature | 1T | 1 |
| 3 | SF3 | How to write a paper | 3T | 3 |
| | | Total | 5 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | An oral examination (30min, weighting 100%). SF2 and SF3 are compulsory. |
| 10 | Student workload: | Weekly 1 h lecture plus 1 h preparation/follow-up work = 30 h;<br>Weekly 4 h tutorial plus 1 h preparation/follow-up work = 75 h;<br>Examination preparation = 45 h<br><br>**SF module total: 150 hours** |

# WAP module

| | | |
|---|---|---|
| 1 | Module name: | **Advanced Polymers core elective module** |
| 2 | Subject area /<br>Responsible for the module: | Materials and Natural Sciences / Polymer Science<br>Chair of Macromolecular Chemistry I & II |
| 3 | Content and qualification objective:<br>a) Content:<br><br>b) Qualification objective: | <br>Basic, as well as advanced knowledge about contemporary issues of polymer synthesis, modification and characterization.<br><br>Advanced knowledge of the synthesis, modification and characterization of polymers. |
| 4 | Prerequisites: | a) general: advanced study skills<br>university courses: Composition and properties of polymers |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | WAP | Advanced Polymers/Polymer Synthesis | 2L + 2T | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (120 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 h;<br>Weekly 2 h practical training plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 45 h<br><br>**WAP module total: 150 hours** |

# WBE module

| | | |
|---|---|---|
| 1 | Module name: | **Bioprocess Engineering core elective module** |
| 2 | Subject area / Responsible for the module: | Engineering Science / Bioprocess engineering<br>Chair of Process Biotechnology |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br>b) Qualification objective: | <br>Operational modes / process conducts of reactors and reactor models, kinetics of biomass and product formation; stoichiometric material flow analysis; purification processes of biotechnological products<br><br>Analysis and modelling of microbial processes and their process engineering dimensioning; ability to develop an efficient bio-pharmaceutical production process. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: none |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | WBE | Bioprocess engineering | 2L + 2T | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 min, weighing 100%) |
| 10 | Student workload: | Weekly 2 h lectures plus 2 h preparation/follow-up work = 60 h;<br>Weekly 2 h tutorial plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 30 h<br><br>**WBI module total: 150 hours** |

# WBI module

| | | |
|---|---|---|
| 1 | Module name: | **Biotechnology core elective module** |
| 2 | Subject area / Responsible for the module: | Engineering Science / Bioprocess engineering<br>Chair of Process Biotechnology |
| 3 | Content and qualification objective:<br>c) Content:<br><br><br><br>d) Qualification objective: | <br>Production organisms, gene technology, genetic engineering, metabolism engineering, synthetic biology, recombinant protein production, Bioprocess design, DoE, catalysis, downstream processes, GMP, process analysis technology (PAT), process validation, quality control, renewable resources<br><br>Ability to develop basic processes for producing products for medical applications; ability to integrate renewable, natural raw materials in the material flows of the pharmaceutical industry. |
| 4 | Prerequisites: | c) general: advanced study skills<br>d) university courses: Biology, Biochemistry, Chemistry (bachelor's level); Mathematics: differential and integral calculus, elementary algebra and polynomial functions, descriptive statistics |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | WBI | Biotechnology | 2L + 2P | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 min) |
| 10 | Student workload: | Weekly 2 h lectures plus 2 h preparation/follow-up work = 60 h;<br>Weekly 2 h practical training plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 30 h<br><br>**WBI module total: 150 hours** |

# WBT module

| | | |
|---|---|---|
| 1 | Module name: | **Bioengineering for Tissue Regeneration core elective module** |
| 2 | Subject area /<br>Responsible for the module: | Engineering Science / Biomedical engineering<br>Chair of Biomaterials |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br><br><br>b) Qualification objective: | <br>Overview of molecular bioengineering, computer modelling of biological and physiological systems, genomics, proteomics and bioinformatics. Insight into biomedical engineering, molecular bioengineering, nerve and cardiac bioengineering, medical imaging, prosthetics, biomechanics; understanding of the cell at the molecular level; applications in various fields of medicine and diagnostics, tissue regeneration and organ replacement.<br><br>Overview of bioengineering techniques; comprehensive knowledge of regenerative medicine, healing technique, computer biology and bioinformatics; competencies in chemical and molecular bioengineering techniques, processing technology, imaging techniques, analytics, cell biology and biomedical applications. Acquisition of systematic methodological competencies for analysing, processing and communication of interdisciplinary science aspects in theory and practice; acquisition of decision-making competence regarding possible technical applications. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: Biology for Engineers, Biochemistry for Engineers |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | WBT | Bioengineering for Tissue Regeneration | 2L + 2T | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination. (60min, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 2 h preparation/follow-up work = 60 h;<br>Weekly 2 h practice plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 30 h<br><br>**WBT module total: 150 hours** |

# WCM module

| | | |
|---|---|---|
| 1 | Module name: | **Drug Chemistry core elective module** |
| 2 | Subject area /<br>Responsible for the module: | Natural Sciences / Chemistry<br>Chair of Organic Chemistry I |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br>b) Qualification objective: | <br>Strategies of drug discovery (lead structure or diversity-oriented), pharmacophore detection, structure-effect relationships, methods of rational design of drugs, as well as structures and mechanisms of selected representatives of clinically important areas (e.g. cytostatics, anti-infectives).<br><br>Knowledge of basic properties of active substances, their rational optimization and the mechanisms of their effect. |
| 4 | Prerequisites: | general: advanced study skills |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | WCM | Drug Chemistry | 2L + 2P | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 h;<br>Weekly 2 h practical training plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 45 h<br><br>**WCM module total: 150 hours** |

# WLA module

| | | |
|---|---|---|
| 1 | Module name: | **Automation Lab Course core elective module** |
| 2 | Subject area /<br>Responsible for the module: | Engineering Science<br>Chair of Measurement and Control Technology |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br><br><br>b) Qualification objective: | <br>Three laboratory experiments conducted in a group on measuring sections, as well as single and multi-variable controls for common control variables (temperature, pressure, level among others). Individual project work with a task from the field of measurement and control technology (examples: computer-based sensing and evaluation of measurement data from a test bench; Controlling an automatic test bench; Realization of temperature control; Programming a microcontroller for radio-based data transmission; ...).<br><br>Consolidation and broadening of knowledge in the field of measurement and control technology; practical experience in the design, operation and optimization of computerized measurement devices and control circuits; Practice in the use of industry-typical hardware and software for data acquisition, for processing and display of measurement data as well as for the parameterization of the controller; Ability to classify the requirements for interfaces and bus systems as well as for systematic incorporation of related tasks. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: Basic knowledge of mathematics, electrical engineering, measurement and control technology |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | WLA1 | Automation Practical Course | 1 | 1 |
| 1 | WLA2 | Automation Study Project | X | 4 |
| | | Total | X | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written report of the individual project work. |
| 10 | Student workload: | Weekly 1 h practical with 1 h preparation/follow-up work = 30 h;<br>Individual project work = 90 h;<br>Report on individual project work = 30 h<br><br>**WLA module total: 150 hours** |

# WPC module

| | | |
|---|---|---|
| 1 | Module name: | **Physical Chemistry of Polymers core elective module** |
| 2 | Subject area /<br>Responsible for the module: | Materials and Natural Science / Polymer Chemistry<br>Physical Chemistry, Professorship of Biofabrication |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br><br><br>b) Qualification objective: | <br>Spatial structure of single macromolecules (radius of gyration and segment density distribution of a Gaussian coil), thermodynamics of polymer solutions (Flory-Huggins theory, osmotic pressure, phase diagrams), polymer analytics (osmosis, viscosimetry, scattering methods, chromatography, mass spectrometry), macromolecules in the melt and the solid state (glass transition, crystallization), basics of mechanical properties (viscoelastic properties, rubbers, rheology).<br><br>The course will provide knowledge about the structure of macromolecules, the thermodynamics of polymer solutions, the molecular characterization of polymers and basics of the properties of polymers in the condensed state (melt and solid state) and of their mechanical properties. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: Composition and properties of polymers |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | WPC | Physical Chemistry of Polymers | 2L + 2T | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (120 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 h;<br>Weekly 2 h tutorial plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 45 h<br><br>**WPC module total: 150 hours** |

# WPM module

| | | |
|---|---|---|
| 1 | Module name: | **Polymer materials core elective module** |
| 2 | Subject area /<br>Responsible for the module: | Natural Sciences / Polymer Chemistry<br>Professorship of Biopolymer Processing |
| 3 | Content and qualification objective:<br>c) Content:<br><br><br><br>d) Qualification objective: | <br>Polymer synthesis procedure; Structure of polymers and polymer compounds; Properties of polymers; Technologies for the production of polymer compounds and polymer components; Ways to test the properties of polymer compounds and polymer components.<br><br>Knowledge of the special properties of polymers and polymer compounds (including time- and temperature-dependent viscoelastic behaviour). Knowledge of the characteristics of the different important manufacturing technologies (polymer synthesis procedure, compounding technology, processing methods such as injection moulding) and the possibilities for influencing the properties of the materials and the products made from these materials. Knowledge of the calculation methods of the complex flow conditions in plastics machinery and tools. |
| 4 | Prerequisites: | general: advanced study skills |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | WPM1 | Polymer Materials: Technology of Polymer Modification | 2L | 3 |
| 1 | WPM2 | Technology of Polymer Modification Practical Course | 2P | 2 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 h;<br>Weekly 2 h practical training plus 2 h preparation/follow-up work = 60 h; Examination preparation = 45 h<br><br>**WCT module total: 150 hours** |

# WSM module

| | | |
|---|---|---|
| 1 | Module name: | **Simulation of Materials core elective module** |
| 2 | Subject area /<br>Responsible for the module: | Materials Science<br>Chair of Biomaterials |
| 3 | Content and qualification objective:<br>a) Content:<br><br><br><br><br>b) Qualification objective: | <br>Simulation of material properties: Flow behavior and self-assembly in polymer systems, structure formation and transport properties in solid state materials. Simulation methods: Molecular dynamics simulation, finite elements (FEM), finite differences (FDM). Simulation software: Handling and data evaluation. Scientific background of simulation methods and model systems.<br><br>Insight into underlying mechanisms of material properties. Practical experience with simulation software handling, choice of suitable parameters, creation of a simulation plan, evaluation and validation of results. Background information of simulation techniques, knowledge about model systems and underlying approximations. |
| 4 | Prerequisites: | a) general: advanced study skills<br>b) university courses: Experimental physics for engineers, technical design and CAD |
| 5 | Possible inclusion in curriculum: | in the first or second semester |
| 6 | Frequency: | yearly |
| 7 | Duration of the module: | 1 semester |
| 8 | Overview and credits: | |

| No. | Abbr. | course | SWS | CP |
|---|---|---|---|---|
| 1 | WSM | Simulation of Materials | 2L + 2T | 5 |
| | | Total | 4 | 5 |

| | | |
|---|---|---|
| 9 | Module examination: | A written examination (60 minutes, weighting 100%) |
| 10 | Student workload: | Weekly 2 h lecture plus 1 h preparation/follow-up work = 45 h;<br>Weekly 2 h tutorial plus 2 h preparation/follow-up work = 60 h;<br>Examination preparation = 45 h<br><br>**WSM module total: 150 hours** |