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Technische Universität Dresden
Biotechnologisches Zentrum

Study regulations for the consecutive master's program Molecular Bioengineering

of xxx

Pursuant to Article 36 of the Law on Institutions of Higher Education in the Free State of Saxony (Sächsisches Hochschulgesetz - SächsHSG) of December 10, 2008 (Saxon law gazette p. 900), amended by article 10 of the law of June 26, 2009 (Saxon law gazette pp. 375, 377), the Technische Universität Dresden enacts the study regulations below as statutes.

(In these regulations masculine designations of persons apply to female persons too.)

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§ 1
Scope

Based on the Saxon Law on Institutions of Higher Education and the examination regulations, these study regulations govern the aims, content, structure and organisation of the consecutive Master's program Molecular Bioengineering at the Technische Universität Dresden.

§ 2
Aims of the program

1) The master's program is more research-oriented. On the basis of the discussed methods and different scientific approaches the students are able to conduct independent scientific research. The students can work on complex problems and solve them with scientific methods that may even lie beyond their current state of knowledge. The students have gained a subject-related expertise that is based on current research questions, methodological and analytical skills enabling them to independently broaden their scientific knowledge. In this, research methods and strategies play a central role. The students are able to think across scientific boundaries, communicate scientifically in a multidisciplinary field and solve economic problems.

(2) Students with a background in either a more technology- or biomedical-oriented field are able to broaden their knowledge in this field and similarly extend their knowledge of the fundamentals of the other. They are able to interrelate contents from technology and biomedicine and focus on specific fields of interest that combine these two.

(3) The students broaden their basic knowledge and their methodological skills. Thus, the students acquire an interdisciplinary research and development competence that qualify them for scientific purposes (PhD, dissertation) as well as the professional field in R&D departments of biotech companies.

(4) A graduate in Molecular Bioengineering has a sound knowledge in molecular and cell biology, biomaterial science and tissue engineering as well as bionanotechnology and bioinformatics. He is able to combine his knowledge of biomedical contents with an engineering approach to current research questions and can such contribute to an efficient technology transfer.

§ 3
Admission requirements

(1) Providing proof of the eligibility (qualification) for the master program Molecular Bioengineering is mandatory for the admission to the program.

(2) To be qualified and, thus, eligible for admission to the Master's program Molecular Bioengineering pursuant to par. 1, a candidate shall

1) furnish evidence of a first university degree in engineering (preferably in Materials Science, Nanotechnology or Computer Science), a medical subject or a natural science.

2) prove his proficiency in English, in case English is not his mother tongue. Evidence may be furnished through common international language tests (preferably IELTS: min. Level 6.0 or TOEFL: 550 points paper-based test).

3) furnish evidence of his qualification for the Master's program Molecular Bioengineering. This includes sound knowledge in biochemistry, cell biology, material science, mathematics and physics. Evidence shall be furnished with the documents as specified by the separate admission regulations (Eignungsfeststellungsordnung).

(3) The admission requirements and admission procedure as well as the appointment and tasks of the selection committee are regulated by a separate document, i.e. the admission regulations.

§ 4
Start and duration of the program

(1) The program generally starts in the winter semester.

(2) The standard period of study is four semesters and includes attendance of the courses as well as self-study, practicals under supervision and the master examination.

§ 5
Types of courses

(1) The structure of the program is modular. The content of the individual modules is conveyed, consolidated and treated in-depth in lectures, exercises, tutorials, seminars and practicals.

(2) In lectures the students are introduced to the topics specified in the module descriptions. In the exercises students apply the theory that they learned in the lectures in exemplary sub-topics. Tutorials refer to the lectures and are intended for a thorough repetition of the lecture content and, if applicable, its in-depth treatment. Seminars are intended for developing the student's ability to deal with a problem mainly on the basis of literature, documentation or other papers, to present the results of his work in written or oral form. Practicals are intended for the practical application and in-depth treatment of the content conveyed in the lectures.

§ 6
Structure and organisation of the program

(1) The structure of the program is modular. Semester 1-3 are dedicated to coursework. The fourth semester is reserved for the writing of the Master's thesis and the defense.

(2) The program consists of 9 compulsory and 2 compulsory optional modules.

(3) The contents and qualification aims, the types of courses, the necessary requirements, workload and duration of the modules are specified in the module descriptions (appendix 1).

(4) The courses are taught in English.

(5) The appropriate distribution of the modules over semester 1-3 ensuring the timely completion of the program in the standard period of study, as well as type and scope of the courses and number and suggested standard date of the course requirements and exams are specified in the study schedule (appendix 2).

(6) Upon proposal by the study committee the Scientific Board of the BIOTEC may update the list of electives and the study schedule. The up-to-date list of electives is published at the beginning of the semester. The modified study schedule is valid for all students whom have been informed. The examination committee decides on exceptions to sentence 3.

§ 7
Contents of the program

(1) The master program Molecular Bioengineering is research-oriented.

(2) The program focuses on the scientific basics and potential applications of molecular bioengineering in medicine and technology.

(3) The study program focuses on the architecture of the genome and mechanisms of change. These are applied in Genome Engineering and model systems. The function of proteins in the cell, in tissue and organisms and the interaction with other proteins is also discussed. Essential aspects to be discussed are the structure of proteins and their dynamic characteristics in cellular functions like cellular signaling processes, cell adhesion, cell movement and cell division. These processes are based on biochemical reactions and metabolic pathways whose systematic manipulation is studied in detail. The basics of biophysics are essential for the observation and manipulation of biological systems; thus in the program dynamics, interactions and structure of biological systems are described with the help of physical principles. Furthermore, the students learn about methods in bioinformatics enabling them to process biological data and investigate their sequence and structure. This knowledge and methods are discussed in an interdisciplinary context taking into account their applications in molecular biology, material sciences, medicine and nanotechnology.

§ 8
Credit Points

(1) The successful progression of the studies as well as the workload for the students is documented by the award of ECTS credits. One credit point is equivalent to a workload of 30 hours. The workload per academic year is typically 60 credit points, i.e. 30 per semester. The total workload for the whole program is 120 credit points and includes the types of courses, course requirements and exams as well as the master thesis and the defence as specified by the module descriptions.

(2) The module descriptions (appendix 1) specify how many credit points are awarded for each module. The credits are obtained when the module examination is passed. Article 27 of the examination regulations remains unaffected.

§ 9
Study counselling

(1) The general study counselling on study opportunities, enrolment procedures and general student affairs is provided by the Student Advisory Service of the Technische Universität Dresden and the BIOTEC student office. Continuous study counselling is provided by the university teachers who are active in the program and the BIOTEC study and examination office. This is to support students especially in matters of study planning as well as the planning of the further career.

(2) Students who have not taken any examinations until the 3rd semester must take part in a study counselling session.

§ 10
Modification of module descriptions

(1) In order to ensure an optimal adaptation to changed conditions, the module descriptions can be modified in a simplified procedure except for the points "module name", "contents and qualification aims", "type of course", "requirements for the award of credits" as well as "credits and grades".

(2) Upon proposal of the study committee the Scientific Board of BIOTEC thus formally resolves upon changes in the module descriptions. The changes shall be published in accordance with the relevant provisions for publications.

§ 11
Transitional Rules

(1) These study regulations are applicable to the students enrolled from winter semester 2010/11.

(2) All students who have been enrolled before winter semester 2010/11 shall complete the program on the basis of the study regulations for the master program Molecular Bioengineering applicable for them.

§ 12
Entry into force and publication

The study regulations shall enter into force on October 1, 2010 and be published in the Official Publications (Amtliche Bekanntmachungen) of the Technische Universität Dresden.

Enacted on the basis of the resolution of the Scientific Board of BIOTEC on ... and the approval of the Rectorate of TU Dresden on ...

Dresden, ...

The Rector of the Technische Universität Dresden

Appendix 1: Module Descriptions for the master's program Molecular Bioengineering
Molecular Bioengineering

Module Number BT-MB 1.1	**Title of the module** Genomes and Evolution	**Responsible Lecturer** Francis Stewart
Content and qualification aims	The students are able to understand the nature of the genome, its architecture, characteristics and variability on a new, integrative level. They are in the position to draw conclusions about the architecture of the genome, its content, as well as the mechanisms of change in evolution. They understand genome maintenance based on the molecular mechanisms of DNA replication and repair, together with analysis of the molecular mechanisms of recombination that maintains and alters both genomes. They are in the position to comprehend both prokaryotic and eukaryotic chromatin and master the basics about epigenetic regulation and RNAi. In addition, they have basic knowledge in genetic engineering. The students have a profound comprehension of the genome and genome engineering, which complements the studies of tissue engineering, bioinformatics and cellular machines. They have an overview of the techniques used in the different fields in genomics (e.g. DNA recombination in bacteria, site-specific and equivalent recombination, recombineering, restriction enzyme and the Southern-Blotting-Method, gel-electrophoresis).	
Type of course	3 SWS lecture and 5 SWS practical course	
Requirements for study	Good understanding of molecular biology (DNA, RNA and central dogma) on bachelor-level, basic knowledge in biochemistry and cell biology on bachelor-level	
Practical use of the module	The module is a compulsory part of the Molecular Bioengineering Master program. It lay the foundations for the module Genome and Stem Cell Engineering.	
Requirements for the award of credits	The credits are awarded if the module examination is successfully passed. The module examination is composed of: • a written examination (duration 120 minutes) • a lab protocol	
Credits and grades	For this module 6 credit points can be acquired. The module grade is the weighted average of • ¾ written examination	

	• ¼ lab protocol
Frequency of the course	The module is offered every winter semester.
Workload	The workload is 180 working hours.
Duration of the module	1 semester
Recommended Literature	• Berg, Tymoczko, Stryer. Biochemistry (5th edition). Freeman ISBN 0-7167-4684-0 • Gesteland, Cech, Atkins. The RNA World (2nd edition), Cold Spring Harbor Laboratory Press. ISBN 087969-589-7 • Kornberg, Baker. DNA Replication (2nd edition). Freeman. ISBN 0-7167-2003-5 • Leach. Genetic Recombination. Blackwell Science. ISBN 0-632-03861-6 • Campbell, Heyer. Discovering genomics, proteomics and bioinformatics. CSHL Press. ISBN 0-8053-4722-4 • Lesk. Introduction to Bioinformatics. Oxford University Press. ISBN 19-925196-7 • Jameson. Principles of Molecular Medicine. Humana Press. ISBN 0-89603-529-8 • Watson, Baker, Bell, Gann, Levine, Losick. Molecular Biology of the Gene (5th edition). CSHL Press. ISBN 0-8053-4635-X

Module Number BT-MB 1.2	**Title of the module** Introduction to Proteomics	**Responsible Lecturer** Bernard Hoflack
Content and qualification aims	The students have a profound comprehension of molecular cell biology as well as protein networks and their influence on cellular functions within individual cells, in tissue and in the whole organism. Through the critical analysis of scientific publications the students have adopted logical and scientific approaches. They know about the applied methods and results in specific fields of research. Due to such literary analysis they acquire a certain scientific maturity. The students have an excellent basic knowledge of proteins and their functional connection in cells. This basic knowledge is required for the profound comprehension of tissue engineering, bioinformatics and cellular machinery. The students possess a basic and practical knowledge to work efficiently in the fundamental and applied research.	
Type of course	3 SWS lecture and 5 SWS practical course	
Requirements for study	Basic knowledge of biochemistry and cell biology on bachelor level	
Practical use of the module	The module is a compulsory part of the Molecular Bioengineering Master program. It lays the foundations for the modules Protein Networks and Protein Engineering as well as Genome and Stem Cell Engineering.	
Requirements for the award of credits	The credit points are awarded if the module examination is successfully passed. The module examination is composed of an oral examination (individual examination, duration 20 minutes).	
Credits and grades	For this module 6 credit points can be acquired. The module grade corresponds to the grade of the examination.	
Frequency of the course	The module is offered every winter semester.	
Workload	The workload is 180 working hours.	
Duration of the module	1 semester	
Recommended literature	• Molecular biology of the Cell (Bruce Alberts) • Molecular Cell Biology (Darnell).	

Module Number BT-MB 1.3	**Title of the module** Chemistry with Biomolecules	**Responsible teachers** Francis Stewart
Content and qualification aim	Based on the chemical and biochemical basic knowledge, the students know which possibilities chemical synthesis *in vitro* and biosynthesis *in vivo* offer for generating molecular diversity. The students know how the applied methods and reaction principles are based on the general principles of chemical and biochemical reactions and which methods are to be applied to create a greater molecular variety. A special focus is laid to the understanding of the interrelation between the basic ways of metabolism and its differing ways, which allow the creation of new molecules. The understanding of approaches in combinatorial biosynthesis is treated in-depth using a practical example for the formation of a modified natural substance. The students have a profound understanding of interfaces for the efficiency of biotechnological products and methods. Thanks to the lecture the students have an overview of the biotechnological relevant phenomena at interfaces. In addition, they know the intermolecular forces, chemical and physical parameters of surfaces as well as concepts for the description of interface phenomena and the presentation of interface-sensitive methods for analysis. Following up, the students have knowledge of the modification of surfaces, functionalization methods for solid material interfaces and especially of techniques for the immobilisation of bioactive molecules. The students are familiar with the basics of creating molecular variety and they are able to connect them with their knowledge from the field of molecular genetics and proteomics.	
Type of course	4 SWS lecture and 2 SWS lab practical	
Requirements for study	Basic knowledge of inorganic and organic chemistry as well as biochemistry and physics on the level of bachelor	
Practical use of the module	The module is compulsory part of the Molecular Bioengineering master program.	
Requirements for the award of credits	The credit points can be acquired, if the module examination is successfully passed. The module examination consists of: • two written examinations (duration 90 minutes each) • and a lab protocol	
Credits and grades	For this module 6 credit points can be awarded. The module grade is the weighted average of • written examinations 2/5 each	

	• lab protocol 1/5
Frequency of the course	The module is offered each academic year starting in winter semester.
Workload	The workload is 180 working hours.
Duration of the module	2 semesters
Recommended literature	• K. P. C. Vollhardt, N. E. Schore: Organic Chemistry: Structure and Function (3rd Edition). W. H. Freeman & Co. 1998. • Nelson/Cox: Lehninger Principles of Biochemistry (3rd Edition) Worth Publishers. 2000 • Glick/Pasternak: Molecular Biotechnology. ASM Press. 1994 • Walsh: Antibiotics – Actions, Origins, Resistance. ASM Press. 2003 • Beck-Sickinger/Weber: Combinatorial Strategies in Biology and Chemistry. Wiley. 2002 • Hiemenz, P.C. Rajagopalan, R.: Principles of Colloid and Surface Chemistry (3rd ed.) Dekker. ISBN: 0-8247-9397-8 • J. Isrealchvili: Intermolecular and Surface Forces. Academic Press. ISBN: 0123751810 • F. Garbassi, M. Morra, E. Occhiello: Surfaces- From Physics to Technology. Wiley. ISBN 0471938173

Module Number BT-MB 1.4	**Title of the module** Bioinformatics	**Responsible Lecturer** Michael Schroeder
Content and qualification aims	The students have knowledge of the basic concept of bioinformatics especially in the field of sequence and structure comparison as well as current issues from bioinformatics. The students are in the position to answer biological questions with the help of online resources. They understand the complexity of the underlying data and methods of analysis and they are able to critically evaluate analyses. They know how to send requests to databases and how to program them. Furthermore, the students can express biological questions as data processing problems and algorithms and they are able to implement them. They are in the position to evaluate the quality of the algorithms critically.	
Type of course	6 SWS lecture and 6 SWS tutorial	
Requirements for study	Basic knowledge of mathematics on Abitur level, practical experience with computers and Internet, basic concepts of molecular biology on bachelor level	
Practical use of the module	The module is compulsory part of the Molecular Bioengineering master program.	
Requirements for the award of credits	The credit points can be acquired, if the module examination is successfully passed. The module examination is a written examination (duration 90 minutes).	
Credits and grades	For the module 12 credit points can be awarded. The module grade corresponds to the grade of the written examination.	
Frequency of the course	The module is offered each academic year starting in the winter semester.	
Workload	The workload is 360 working hours.	
Duration of the module	3 semesters	
Recommended literature	• Artur Lesk: Introduction to Bioinformatics. Oxford University Press. 2002 • Paul DuBois, MySQL Cookbook, O'Reilly • James Tisdall, Beginning Perl for Bioinformatics, O'Reilly • Kinser. Python For Bioinformatics • Eidhammer, Jonassen, Taylor. Protein Bioinformatics: An algorithmic approach to sequence and structure analysis. Wiley	

Module Number BT-MB 1.5	**Title of the module** Biophysics	**Responsible Lecturer** Petra Schwille
Contents and qualification aim	The students are provided with a comprehensive overview of the most frequently applied techniques and their physical basics: basics of physical measuring, methods for the determination of macromolecular structures, methods for analyzing molecular dynamics and interactions, imaging methods in cell biology, mechanical methods (measurement of force, rheology), electro-physiological methods, modern technologies (biochips, single-molecule- techniques). The students know current examples of the respective techniques in their application concerning biological questions and they gain a good insight into certain work steps of these techniques. On the one hand, the students understand the relevance of physical concepts and working methods such as finding concepts, modelling, application of basic and advanced mathematical methods. On the other hand, they are working with a targeted-oriented working method, i.e. they can realise quickly which physical models are applicable to which biological and biotechnological problems and which questions can be answered with the help of physical methods. The students know the fundamentals of thermodynamics, concepts of energy and entropy, transport phenomena, biologically acting forces, classic reaction and enzyme kinetics, bioenergetics, biomechanics, membrane biophysics with electro-physiological fundamentals. The students have an overview of biological phenomena that motivate or require a physical approach. They can identify inexact or insufficient quantitative descriptions within the practical-oriented education in modern biosciences and improve them by adequate modelling and the development of suitable control measurements in the field of experimentation. The students know the most important mathematical basics and steps and lose their timidity to approach biological phenomena from a quantitative perspective.	
Type of course	4 SWS lecture, 2 SWS seminar, 2 SWS exercise and 1 SWS practical	
Requirements for study	Mathematical fundamentals of differential and integral calculus on Abitur level, fundamentals of classical physics (mechanics, electrodynamics, heat) on Abitur level	
Practical use of the module	The module is compulsory part of the Molecular Bioengineering master program.	
Requirements for the award of credits	The credit points can be acquired, if the module examination is successfully passed. The module examination consists of: • an oral presentation	

	• a written examination (duration 90 minutes) • and a lab protocol
Credits and grades	For this module 12 credit points can be awarded. The module grade is the weighted average of • 2/5 oral presentation • 2/5 written examination • 1/5 lab protocol
Frequency of the course	The module is offered every winter semester.
Workload	The workload is 360 working hours.
Duration of the module	1 semester
Recommended Literature	• T. Furukawa: Biological Imaging and Sensing • J. Pawley: Handbook of Confocal Microscopy • E. de Hoffmann, V. Stroobant: Mass Spectrometry • T. Basche, W.E. Moerner M. Orrit: Single Molecule Optical Detection, Imaging, and Spectroscopy • P. Nelson: Biological Physics • R. Cotterill: Biophysics • R. Glaser: The Physical Basis of Biochemistry • C.R.Cantor, P.R. Schimmel: Biophysical Chemistry • H.C. Berg: Random Walks in Biology. • P.W. Atkins: Physical Chemistry • P.W. Atkins: The Elements of Physical Chemistry. • J. Wymen: Binding and Linkage. • D.H. Boal: Mechanics of the Cell • J. Howard: Mechanics of the Cytoskeleton • D.T. Haynie: Biological Thermodynamics • D.G. Nicholl: Bioenergetics.

Module Number BT-MB 2.1	**Title of the module** Genome and Stem Cell Engineering	**Responsible Lecturer** Francis Stewart
Content and qualification aim	The students are provided with an overview of the development of mammalian embryos and the genetic manipulation of embryonic stem cells. In addition to that they know the biology of embryonic stem cells, signal streams and transcriptional networks in embryonic stem cells as well as the differentiation of ES – cells. The students are familiar with potential applications of stem cell methods for the tissue construction and regenerative medicine, including nuclear cloning, inducible reprogramming and gene therapy-strategies. The students understand the basics of Genome Engineering and its application for important model systems. They have a comprehensive understanding of Genetic - Engineering, stem cell biology and reprogramming. They have a fundamental and practical knowledge in order to work efficiently in the fundamental and applied research.	
Type of course	4 hours lecture and 6 hours practical	
Requirements for study	Competences and skills of the modules Genomes and Evolution and Introduction to Proteomics	
Practical use of the module	The module is compulsory in the Molecular Bioengineering Master program.	
Requirements for the award of credits	The credit points can be acquired, if the module examination is successfully passed. The module examination consists of: • an essay (24 working hours) • an oral presentation • and a lab protocol	
Credits and grades	For the module 9 credit points can be acquired. The module grade is composed of the weighted average grades of the examinations: • 2/5 essay • 2/5 oral examination • 1/5 lab protocol	
Frequency of the course	The module is offered every academic year and starts in summer semester.	
Workload	The workload is 270 working hours.	
Duration of the module	2 semesters	
Recommended Literature	• Biochemistry (5th edition), Jeremy M. Berg, John L. Tymoczko, Lubert Stryer; ISBN 0-7167-4684-0, Freeman • The RNA World (2nd edition), Gesteland, Cech, Atkins; ISBN	

	087969-589-7, Cold Spring Harbor Laboratory Press • DNA Replication (2nd edition), Kornberg, Baker, ISBN 0-7167-2003-5, Freeman • Genetic Recombination, Leach, ISBN 0-632-03861-6, Blackwell Science • Discovering genomics, proteomics and bioinformatics, Campell, Heyer, ISBN 0-8053-4722-4, CSHL Press • Introduction to Bioinformatics, Lesk, ISBN 19-925196-7, Oxford University Press • Principles of Molecular Medicine, Jameson, ISBN 0-89603-529-8, Humana Press • Molecular Biology of the Gene (5th edition), Watson, Baker, Bell, Gann, Levine, Losick, ISBN 0-8053-4635-X, CSHL-Press • Handbook of Stem Cells, Robert Lanza, ed, Elsevier in press

Module Number BT-MB 2.2	**Title of the module** Protein Networks and Protein Engineering	**Responsible Lecturer** Bernard Hoflack
Content and qualification aim	The students are able to describe the protein structure and the resulting supramolecular structures, which are regulated by special protein networks. They know the dynamic of such supramolecular structures, which are examined within the framework of basic cellular functions such as cell adhesion, cell movement and cytokinesis. The students know the dynamic aspects of cellular signal processes, extracellular matrix proteins, cell adhesion, cytoskeleton and cell movement. The students know the most important biological techniques and methods, e.g. gel electrophoresis, image analysis, mass spectrometry, peptide sequencing. They have fundamentals in general applied methods for the production, cleaning and analysis of proteins and protein networks and classical as well as new technologies for the identification of protein-protein-interactions. The students are provided with a theoretical-critical knowledge, which is completed, by experiments and general techniques of protein analysis (expression of recombinant proteins in E.coli, purification of proteins, analysis of proteins by 1D and 2D gels, western blotting, mass spectrometry, expression of proteins in mammalian cells and visualization by fluorescence microscopy). The students have a basic and practical knowledge in order to work efficiently in the fundamental and applied research.	
Type of course	4 hours lecture and 6 hours practical	
Requirements for study	Basic knowledge on bachelor level in genomics, tissue engineering, bioinformatics, cellular machines, biophysics; competences and skills of the module Introduction to Proteomics	
Practical use of the module	The module is compulsory in the Molecular Bioengineering Master program.	
Requirements for the award of credits	The credit points can be awarded, if the module examination is successfully passed. The module examination consists of 2 oral examinations (individual examinations, duration 20 minutes each)	
Credits and grades	For the module 9 credit points can be awarded. The module grade is composed of the unweighted average grades of the respective examinations.	
Frequency of the course	The module is offered every academic year and starts in summer semester.	
Workload	The workload is 270 working hours.	
Duration of the	2 semesters	

module	
Recommended literature	• Molecular biology of the Cell (Bruce Alberts) • Molecular Cell Biology (Darnell). • Introduction to Proteomics (D.C. Leibler, Humana Press) • Protein protocols (J.M. Walker, Humana Press) • Purifying proteins for proteomics (R.J. Simpson, (CSHL press) • Protein-Protein interactions (E. Golemis, CSHL) • Antibodies (D. Lane, CSHL Press) • RNAi, a guide for gene silencing (G.J. Hannon, CSHL Press).

Module Number BT-MB 2.3	**Title of the module** Bionanotechnology and Polymeric Materials	**Responsible Lecturer** Carsten Werner
Content and qualification aim	The students are provided with an overview of the emerging interdisciplinary field bionanotechnology and of the material scientific aspects of polymer chemistry. They are able to combine approaches from chemistry, biology, engineering sciences (particularly of materials sciences) and physics and make use of synergies. The students can find problem-oriented approaches and are in the position to develop those by themselves. The students have learned about different biomimetic techniques to create nanostructures. On the one hand, students know the underlying principles using the example of biomineralization. Several substantial theoretical basics for nanostructural synthesis of diluted solutions are discussed at the same time. On the other hand, they know how DNA can be used to construct synthetic structures on the nanometre scale and what important role the specific structural, chemical and physical characteristics of the molecules play in this context. Another topic is the approach of supramolecular chemistry for the production of nanoscopic objects. The students recognize that even complex biological structure synthesis processes can be detected with simple mathematic and physical models. They have basic knowledge of important methods of structure determination and the measuring of physical characteristics of biomolecules. In addition to that the students know concepts and methods of the molecular design of biomaterials based on polymers. The students know the currently applied materials as well as their field of application in medical engineering including the respective requirements and problems. The students know concepts for biocompatible materials for the application in contact with blood; whereas the attention is especially directed to the possibility of bioinert and bioactive materials and the use-oriented tests that are applied in their development. Furthermore, the students are familiar with tasks concerning the use of biomaterials in regenerative therapies. In this context they have a good knowledge of "cell-scaffolds" based on biopolymers of the extracellular matrix as well as synthetic polymer networks with bioactive components. The students gain an insight in modern research and development activities in the field of biomaterials and they obtain starting points for their own research work.	
Type of course	4 hours lecture and 2 hours practical	
Requirements for study	Advanced knowledge in biology, chemistry and physics on Abitur level as well as a general basic understanding in natural sciences on	

	bachelor level
Practical use of the module	The module is compulsory in the Molecular Bioengineering Master program.
Requirements for the award of credits	The credit points can be awarded, if the module examination is successfully passed. The module examination contains: • an oral examination (individual examination, duration 20 minutes) • and a written examination (duration 90 minutes)
Credits and grades	For this module 6 credit points can be acquired. The module grade is composed of the unweighted average of the grades of the examinations.
Frequency of the course	The module is offered every academic year starting in the summer semester.
Workload	The workload is 180 working hours.
Duration of the module	2 semesters
Recommended Literature	• K. E. Drexler: Nanosystems - molecular machinery, manufacturing, and computation. J. Wiley. 1992 • M. Wilson et al.: Nanotechnology - basic science and emerging technologies. Chapman & Hall/CRC. 2002 • E. Baeuerlein, P. Behrens, M. Epple (Eds.): Handbook of Biomineralization. Wiley-VCH. 2007 (3 Vol.) • S. Mann: Biomineralization - principles and concepts in bioinorganic materials chemistry. Oxford University Press. 2001 • S. Mann: Biomimetic Materials Chemistry. VCH Publishers. 1996 • J. W. Steed, J. L. Atwood: Supramolecular Chemistry. Wiley, Chichester (UK) 2000 • D. S. Goodsell: Bionanotechnology - lessons from nature. J. Wiley. 2004 • J. Howard: Mechanics of motor proteins and the cytoskeleton. Sinauer Associates. 2001 • Niemeyer & Mirkin (eds.) Nanobiotechnology I + II. Wiley Verlag. Weinheim. 2004/2007 • B. D. Ratner, A. S. Hoffman, F. J. Schoen, J. E. Lemons, Biomaterials Science, Academic Press, San Diego 1996. • R. P. Lanza, R. Langer, W. L. Chick, Principles of Tissue Engineering, Academic Press/Landes Bioscience, San Diego/Austin 1997.

Module Number BT-MB 2.4	**Title of the module** Cellular Machines	**Responsible Lecturer** Stefan Diez
Content and qualification aim	The students know new potentials for development of molecular bioengineering as they understand and use cellular machines, especially: (i) construction and function of lipid membranes as well as associated membrane proteins (pores, triggered channels, pumps, carrier), (ii) molecular activities of the energy transformation, interaction and folding of protein structures, (iv) construction and function of DNA and associated proteins, (v) molecular mechanisms of signal transduction and protein degradation, (vi) classification and function of viruses, (vii) structure and dynamic of different filament systems of the cytoskeleton, (viii) motor proteins of the cytoskeleton as high efficient energy transformer, (ix) measuring and prediction of collective effects by the production of force, (x) sub cellular mechanosystems with importance for the cytokinesis and intracellular transport, (xi) cellular motility and (xii) biomolecular sensor system of force. The students are able to interrelate the already acquired knowledge in molecular cell biology, biochemistry, proteomics, biophysics and bionanotechnology and they know concepts of functional biomolecular units as machines, with the specific aim to use them in complex technological or medical processes as nanoscaled functional components. The students have an interdisciplinary research and development competence, which qualifies them both for scientific intentions (master thesis or rather subsequent doctorate) as well as for an activity in the R&D field of a biotechnology company.	
Type of course	4 hours lecture, 4 hours seminar and 2 hours practical	
Requirements for study	Basic knowledge in molecular biology, biochemistry, physics and the chemical implication of the single molecule aspect on bachelor level	
Practical use of the module	The module is compulsory in the Molecular Bioengineering Master program.	
Requirements for the award of credits	The credit points can be awarded, if the module examination is successfully passed. The module examination contains: • an oral presentation, • an oral examination (individual examination, duration 15-20 minutes) • and a lab protocol.	
Credits and grades	For this module 12 credit points can be awarded. The module grade is the weighted average of: • 30% oral presentation	

	• 50% oral examination • 20% lab protocol
Frequency of the module	The module is offered every academic year starting in summer semester.
Workload	The workload is 360 working hours.
Duration of the module	2 semesters
Recommended Literature	• Alberts et al: Molecular Biology of the cell • Berg, Tymoczko, Stryer: Biochemistry (5th edition). Freeman. ISBN 0-7167-4684-0 • Nelson & Cox: Principles of Biochemistry. Worth Publishers. New York. ISBN: 1-57259-153-6 • Pollard & Earnshaw: Cell Biology. Saunder. Pennsylvania. ISBN:0-7216-3997-6 • Branden & Tooze: Introduction to Protein Structure. Garland Piblishers. New York. ISBN: 0-8153-2305-0 • Schulz & Schirmer: Principles of Protein Structure. Springer Verlag. New York. ISBN: 3-540-90334-8 • Israelachvili: Intermolecular & Surface Forces Academic Press. London. ISBN: 0-12-375181-0 • Walsh: Proteins: Biochemistry and Biotechnology. Wiley&Sons. New York. ISBN: 0-471-899070 • Devlin: Textbook of Biochemistry with Clinical Correlations. Wiley&Sons. New York. ISBN: 0-471-411361 • Howard: Mechanics of Motor Proteins and the Cytoskeleton. Sinauer. (2001)

Module Number BT-MB 2.5 A	**Title of the module** Application in Biomedicine	**Responsible Lecturer** Denis Corbeil
Content and qualification aim	The students are given an overview of organ systems from an interdisciplinary physiological, anatomical and biochemical perspective. They know the description of pathological processes and its consequence of organ and tissue failure. They have knowledge of organ conservation, organ culture, organ transplantation and immunological processes. Furthermore, the students are able to isolate and characterise stem cells and they know the basics of the usage of artificial carriers/scaffolds of cells and tissues. Characteristics and compatibility of biomaterials are also discussed. The students have sound knowledge of the construction and function (of anatomy, biochemistry and physiology) of tissues and organs in molecular medicine. The students develop a feeling for biological objects, their dimensions and characteristics while working on histological preparations as well as on preparations of cell cultures. The students know the most important metallic and ceramic biomaterials with their characteristics and user profile as direct biomaterials as well as in applications in sensor and tissue engineering. The students know the general and material-specific interactions between these materials and biological systems. They know the mechanical properties of the different material groups for static and dynamic load in terms of structure-property relationships and they can contrast them with those of biological systems. The focus is especially on important parameters for the design of implants. This enables the students to a comparative discussion and use-oriented choice of material groups based on their characteristics. Besides the metallic biomaterials (metal alloys, cobalt alloys, stainless steels, shape memory alloys and titanium alloys) and ceramic biomaterials (calcium phosphate phases, Al2O3, ZrO2) for specific applications, the students know a variety of processes to adapt the surface properties in terms of biocompatibility and biofunctionality. The students are familiar with different approaches to adjust physical, chemical and biochemical surface properties and they know how to apply them in terms of specific clinical questions. In addition, the students are well informed about highly topical research subjects in the field of molecular cell biology and tissue engineering and they are able to deal with the exchange of scientific results. They have the competence to participate in international conferences and the critically evaluate scientific presentations. Furthermore, the students are able to take on a labour and industry perspective of biotechnology. They know the aspects of technology transfer and utilisation of biotechnological inventions, ethics and possible applications of biotechnology, theoretic and practical aspects	

	for business start-ups, innovation management in small and medium-sized companies as well as transfer projects in the academic field. They know aspects of financial planning and creation of business plans. Besides they are also familiar with assessment and aspects of personnel management. The students know essential aspects of the foundation of an enterprise, instruments of technology transfer as well as of the economic development of the biotechnology industry. In addition, they have the chance to understand, discuss and analyse debates about moral values better. The students know about the social relevance as well as about ethical, economic and juristic aspects of their studies. They have an interdisciplinary research and development competence, which qualifies them for scientific purposes (Master thesis or rather a subsequent doctorate) and for activities in the field of research and development of a biotechnology company.
Type of course	4 hours lecture, 3 hours seminar and 3 hours practical
Requirements for study	Basic knowledge in molecular and cell biology, anatomy, material science, chemistry and biochemistry on bachelor level
Practical use of the module	The module is one of two elective modules in the Molecular Bioengineering master program. Students need to choose one.
Requirements for the award of credits	The credit points can be awarded, if the module examination is successfully passed. The module examination consists of: • a written examination (duration 90 Minutes) • an oral examination (individual examination, duration 20 minutes) • an oral presentation or an essay (of about 24 working hours) at the choice of the student • and a written report/elaboration
Credits and grades	For the module 12 credit points can be awarded. The module grade is the unweighted average of the grades of the examinations
Frequency of the course	The module is offered every academic year starting in summer semester.
Workload	The workload is 360 working hours.
Duration of the module	2 semesters
Recommended literature	• Palsson & Bhatia: Tissue Engineering. • Atala & Lanza: Methods of Tissue Engineering • Morgan & Yarmush: Tissue Engineering Methods and Protocols (Methods in Molecular Medicine,18) • Metals as Biomaterials, Edited by J. A. Helsen and H. J. Breme; John Wiley & Sons Ltd., 1998

	• Titanium in Medicine, Edited by Brunette D.M., Tengvall, P., Textor, M., Thomsen, P.; Springer, Berlin, Heidelberg, 2001. • Bioceramics in Joint Arthoplasty, Edited by M.D. von Zippel; Verlag Dr. Dietrich Steinkopf, 2003. • Biomaterials – Hard Tissue Repair and Replacement, Edited by D. Muster; North Holland 1992 • Tissue-Biomaterial Interactions, Edited by Rene Bizios and David Puleo; John Wiley & Sons Ltd. 2002 • Biomaterials Science and Biocompatibility, Edited by Frederick Silver and D.L. Christiansen; Springer Berlin, 1999.

Module Number BT-MB 2.5 B	**Title of the module** Application in Technology	**Responsible Lecturer** Hans-Georg Braun
Content and qualification aim	The students have a basic overview of the extremely fast developing fields of application-oriented micro and nanostructure technology. Apart from the classic methods of optical and e-beam lithography, this module deals with methods for a 3D patterning and methods for the fast replication of micropatterns, as they are used especially in the fields of nanoanalytics (Lab on a chip), tissue engineering and the biomimetic material development. In this context the students are acquainted with techniques for the local chemical and/or biological surface functionalisation allowing for a location-specific immobilisation of biomolecules. They have a basic knowledge of the physical – chemical behaviour especially of liquid phases in micro systems and on micro-heterogeneous surfaces. Furthermore the students are acquainted with modern methods of the controlled "bottom-up" production of artificial nanostructures and their structural characterisation as well as their potential for application in microsensor technology. On the basis of the necessary basic knowledge from material sciences, physical chemistry, surface chemistry and physics they are able to familiarize themselves with the fast developing field of research of lab-on a chip technologies and to understand new developments. The students know how to produce microstructures with methods of electron beam lithography and soft lithography. Further, the students are able to assemble monodisperse micro particles applied for the solution of diverse analytic and diagnostic questions. In order to characterize the particles the students are familiar with the basics of grid electron microscopy. The students have the competence to handle physical properties of inorganic and biological nanostructures. Systematically they are acquainted with various topical fields of applied bionanotechnology, always in comparison with alternative physical or chemical technologies and especially with the possible risks of nanotechnology. The students know the following topics: manipulation of biological probes in hydrodynamic and electric fields; synthesis and characteristics of metallic and semiconductor clusters in terms of their use for biological detection; properties of carbon nanotubes and their application as highly sensitive biosensors; production of ultra-thin films and layers systems, synthetical nanocomposites, biocers (immobilisation of biomolecules and microorganisms in xerogels and ceramics), adhesion by nano structuring (Gecko), health risks of nano particles. The students have basic knowledge about the most important methods of structure determination of biomolecules and nanostructures. They know that applications of bionanotechnology are already technically used and that the transfer and application of	

	biological principles and methods offer chances and prospects for the future. In addition, the students are well informed about highly topical research subjects in the field of nano(bio)technology and they are able to deal with the exchange of scientific results. They have the competence to participate in international conferences and the critically evaluate scientific presentations. Furthermore, the students are able to take on a labour and industry perspective of biotechnology. They know the aspects of technology transfer and utilisation of biotechnological inventions, ethics and possible applications of biotechnology, theoretic and practical aspects for business start-ups, innovation management in small and medium-sized companies as well as transfer projects in the academic field. They know aspects of financial planning and creation of business plans. Besides they are also familiar with assessment and aspects of personnel management. The students know essential aspects of the foundation of an enterprise, instruments of technology transfer as well as of the economic development of the biotechnology industry. In addition, they have the chance to understand, discuss and analyse debates about moral values better. The students know about the social relevance as well as about ethical, economic and juristic aspects of their studies. They have an interdisciplinary research and development competence, which qualifies them for scientific purposes (Master thesis or rather a subsequent doctorate) and for activities in the field of research and development of a biotechnology company.
Type of course	4 hours lecture, 4 hours seminar and 2 hours practical
Requirements for study	Knowledge in biology, physics and chemistry on bachelor-level, competences and skills of the module Chemistry with Biomolecules
Practical use of the module	The module is one of two elective modules in the Molecular Bioengineering Master Program. Students need to choose one.
Requirements for the award of credits	The credit points can be awarded, if the module examination is successfully passed. The module examination consists of: • 2 oral examinations (individual examination, duration 20 minutes each) • an oral presentation or an essay (of about 24 working hours) at the choice of the student • and a written elaboration report
Credits and grades	For the module 12 credit points can be awarded. The module grade is the unweighted average of the grades of the examinations

Frequency for the course	The module is offered every academic year starting in summer semester.
Workload	The workload is 360 working hours.
Duration of the module	2 semesters
Recommended literature	• Xia, Y. and Whitesides, G. M. Soft Lithography. Angew. Chem. Int. Ed. Engl. 1998,37, 550-575. (Review Article) • Choi, J.W.: Fabrication of 3D biocompatible/biodegradable micro-scaffolds using dynamic mask projection microstereolithography. Journal of Materials Processing Technology 2009 ,209, 5494 -5503 • Falconnet, D. and Csucs, G. and Grandin, H. M. and Textor, M.: Surface engineering approaches to micropattern surfaces for cell-based assays (Review) Biomaterials 2006, 27, 3044–3063 • Rai-Choudhury, P. (ed.): SPIE Handbook of Microlithography, microtechnology and micromachining Vol. 1. ISBN 0-8194-2378-5 – Chapter 1,2,4,5 • A.W. Adamson, A.P. Gast: Physical chemistry of surfaces. Wiley-Interscience. 1997 • R. Wiesendanger, H.J. Güntherodt: Scanning tunneling microscopy I-III. Springer Verlag. 1993 • S.N. Magonov, M.H. Whangbo: Surface Analysis with STM and AFM. VHC Publisher. New York. 1996 • C.M. Niemeyer, C.A. Mirkin: Nanobiotechnology: Concepts, Applications and Perspectives. Wiley-VHC. Weinheim. 2004 • M. Köhler, T. Mejevaia, H.P. Saluz: Microsystems Technology: A Powerful Tool for Biomolecular Studies. Birkhaeuser Verlag. 1999. • K.E. Drexler: Nanosystems - molecular machinery, manufacturing, and computation. J. Wiley. 1992 • M. Wilson et al. Nanotechnology - basic science and emerging technologies. Chapman & Hall/CRC. 2002 • S. Mann: Biomimetic Materials Chemistry. VCH Publishers. 1996 • D.S. Goodsell: Bionanotechnology - lessons from nature. J. Wiley 2004 • Ch. S. S. R. Kumar (Ed.): Nanomaterials – Toxicity, health and environmental issues. Wiley-VCH. Weinheim. 2006 • K. Autumn, N. Gravish: Gecko adhesion: evolutionary nanotechnology. Phil. Trans. Royal Soc. A 2008, 366, 1575-1590; • Niemeyer & Mirkin (eds.): Nanobiotechnology I + II. Wiley Verlag. Weinheim. 2004/2007 • Kelsall, Hamley, Geoghegan (eds.) Nanoscale science and technology. Wiley Verlag. Weinheim. 2005 • Blügel et al. (eds.) Fundamentals of nanoelectronics. 34th IFF Spring School 2003. Schriften des Forschungszentrums Jülich. Vol. 14. 2003.

Appendix 2 – Study schedule of the master program Molecular Bioengineering
defining type and scope of the courses (in SWS) as well as number of exam requirements whose type, scope and organisation are specified in the module descriptions

Number of module	**Title of module**	**1. Semester L/E/S/P/T**	**2. Semester L/E/S/P/T**	**3. Semester L/E/S/P/T**	**4. Semester L/E/S/P/T**	**Credits**
BT-MB 1.1	Genomes and Evolution	3/0/0/5/0 2xPL				6
BT-MB 1.2	Introduction to Proteomics	3/0/0/5/0 1xPL				6
BT-MB 1.3	Chemistry with Biomolecules	4/0/0/0/0 2xPL	0/0/0/2/0 1xPL			6
BT-MB 1.4	Bioinformatics	2/0/0/0/2	2/0/0/0/2	2/0/0/0/2 1xPL		12
BT-MB 1.5	Biophysics	4/2/2/1/0 3xPL				12
BT-MB 2.1	Genome and Stem Cell Engineering		2/0/0/3/0 2xPL	2/0/0/3/0 1xPL		9
BT-MB 2.2	Protein Networks and Protein Engineering		2/0/0/3/0 1xPL	2/0/0/3/0 1xPL		9
BT-MB 2.3	Bionanotechnology and Polymeric Materials		2/0/0/1/0 1xPL	2/0/0/1/0 1xPL		6
BT-MB 2.4	Cellular Machines		2/0/2/2/0 2xPL	2/0/2/0/0 1xPL		12
BT-MB 2.5 A * BT-MB 2.5 B	Application in Biomedicine Application in Technology		2/0/0/2/0 1xPL 2/0/0/1/0 1XPL	2/0/3/1/0 3xPL 2/0/4/1/0 3xPL		12
					Master thesis	29
					defense	1
Total credits		30	30	30	30	120

* students choose 1 out of 2

SWS: Semesterwochenstunden (hours per week, 1SWS=45 min per week over the whole semester), PL: Prüfungsleistung (examination)
L: Lecture, E: Exercise, S: Seminar, P: Practical, T: Tutorial