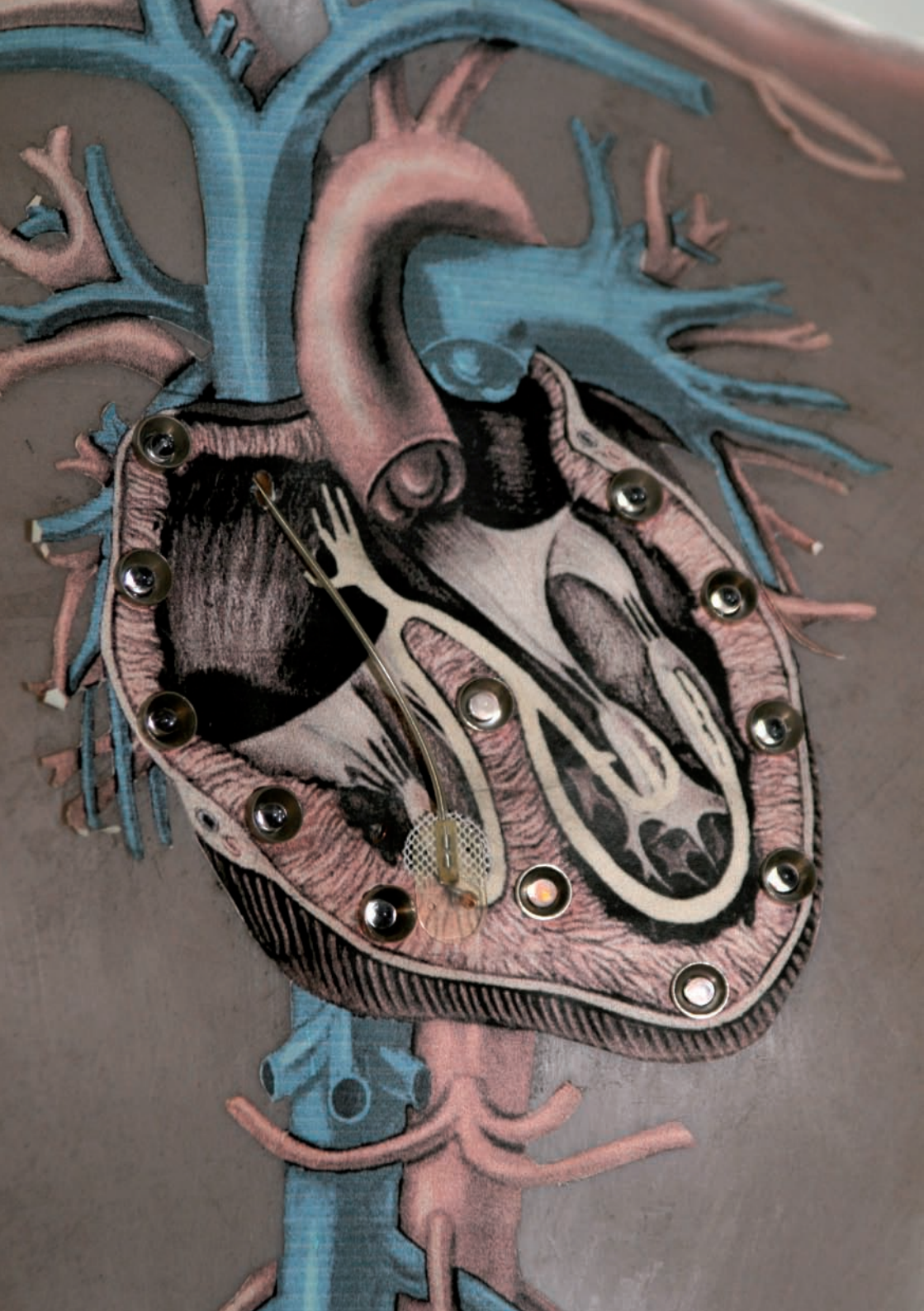
Biomedical Engineering
Master of Science

FACULTY 09
MEDICAL ENGINEERING AND TECHNOMATHEMATICS

FH AACHEN
UNIVERSITY OF APPLIED SCIENCES



Biomedical Engineering

Before you start

General Information

You will find all relevant information with respect to the course of studies Biomedical Engineering in the internet. For that purpose, just photograph the QR code and use the adequate reader of your mobile phone*.

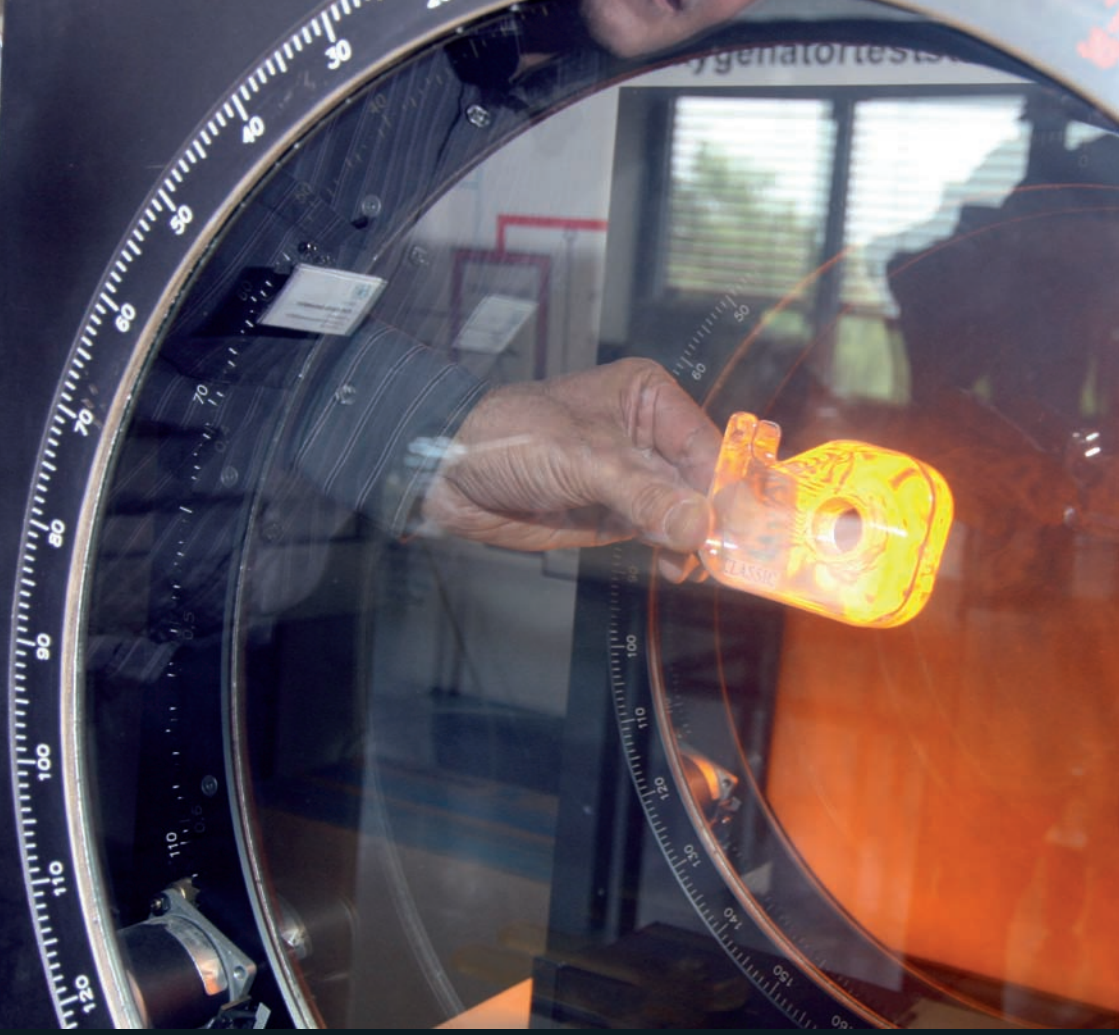
* Please note: Costs may arise upon initiating the web page.

Introducing the degree programme

The Master of Science programme in Biomedical Engineering at the University of Applied Sciences Aachen is an interdisciplinary and internationally oriented study providing students with state of the art scientific knowledge. Additionally, our faculty being scientifically active at the frontiers of science and technology provides in-depth scientific skills and methods in the field of biomedical engineering. This will lead to a scientific qualification and autonomy in this discipline. Graduates will also achieve the necessary qualifications to pursue a doctoral degree.

Our Faculty leads the co-operation between university members representing academics in Medicine, Mathematics, Computer Sciences, Natural Sciences, Mechanical Engineering, Electrical Engineering and Information Technology. The design of the programme takes full advantage of the scientific environment offered by the FH Aachen and its research labs. The scientific themes of our research students will not only be sharing during their studies but also during their MSc or PhD thesis work. The Biomedical Engineering master study takes particular advantage of well-equipped scientific labs that are working in close collaboration with the Research Centre Jülich and our engineering faculties in the city of Aachen. The Master's programme study courses have a modular design and are divided into bridging modules, general compulsory courses, specialised modules, and optional courses. The Master's thesis typically occupies the final six months of the programme. The curriculum and course contents are structured according to the ECTS (European Credit Transfer System) allowing students to study partly at other European universities. Our faculty provides the opportunity to perform internships in biomedical engineering related organisations outside the university.

Last but not least, students showing excellent performance will have the chance to join a PhD study in close cooperation with other German or foreign universities.



Biomedical Engineering

Why Biomedical Engineering?

What is Biomedical Engineering?

Biomedical Engineering (also known as Medical Engineering) is one of the key technologies worldwide. It is based on the basic principles of engineering and combines fields at the borders of medicine, technology and biological sciences. Through interdisciplinary collaboration, solutions are developed for many of the comprehensive problems that arise due to the increasing mechanization of medicine. Today, the entire medical-technical industry is one of the most innovative future-oriented industries in Germany. The innovations center particularly on:

- Improved diagnostics for the early diagnosis of internal injuries, possible tissue engineering applications
- Therapy for an ideal healing process with minimal exposure/stress for the patient, rehabilitation
- Replacement and support of damaged organs, bones or joints by artificial and partly controllable elements
- Improved communication (e.g. telemedicine) and
- Economics

Products are roughly divided into two categories:

Industrial goods | medical instruments, devices and systems. These include all products used in a hospital or in a medical practice:

- Medical supply units
- Inhalation devices
- Anaesthetic devices
- Oxygen devices
- Surgical instruments
- Endoscopes (optical-medical devices)
- Devices for ophthalmology
- Sterilizers
- Surgery equipment
- Examination stools
- Microscopes
- Sensors and blood pressure meters (sphygmomanometers).

Durable and convenience goods | dressing materials, plasters, and medical additives:

- Incontinence, stoma and wound treatment products
- Products necessary for disabled or sick people and for rehab patients: wheelchairs, walking aids, fit components, prostheses, ortheses, medical bandages and compression hosiery
- Devices of respiratory home therapy
- Disposable products such as syringes, catheters and cannulas
- Implants such as artificial joints, cochlea and retina implants, intraocular lenses, pacemakers and artificial heart.

What do Biomedical Engineers do?

The increasing automation of medicine in diagnosis and therapy and the relevance of the environment on health care require an intensive collaboration between physicians, scientists and specially educated engineers. Biomedical Engineers understand the mechanics connected with this field and are often involved in the development and manufacturing of devices, prostheses or related products. Biomedical Engineers also play a vital role in biological work groups such as those that center on cellular and tissue engineering, where they evaluate material properties or the control of mechanical properties in studies.

Biomedical Engineers work with other healthcare professionals, including physicians, nurses, therapists and medical technicians, to design instruments, devices and software, to develop new engineering methods and to research clinical problems.

In Germany, Biomedical Engineering is a multidisciplinary and widely-diversified field of application and research which is distinguished by its high innovation and high quality development. Biomedical engineers have, for example, developed infusion pumps, complete joint replacements, the artificial kidney, highly complex image processing and even robotics.

What Specializations are possible?

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Biomedical engineers specialize in several different clinical fields including:

- Anaesthetics and ventilation
- Audiology
- Orthopaedics
- Electrical devices and sensors
- Medical informatics
- Ophthalmology
- Physiological measurements
- Hardware management
- Rehabilitation technique.

The Career opportunities within Biomedical engineering include:

- Research and development
- Medical equipment technology and product design
- Biomedical applications
- Production and application engineering
- Quality management
- Customer service and technical support
- Service and consulting
- Regulatory affairs
- Hospital management

Typical Fields of Work

The diversity of the study opens up numerous possibilities

Biomedical Engineers design and develop:

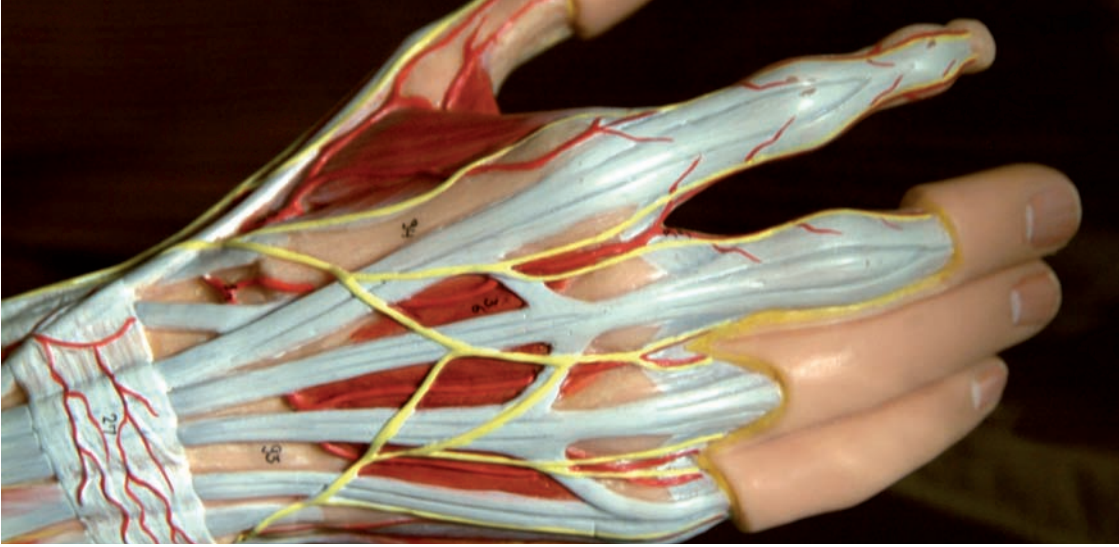
Artificial Limbs | replacement of parts of the upper and lower limbs that were damaged by illness or trauma. Engineers in this field work for numerous European manufacturers.

Orthopedic Implants | The replacement of human joints and the repair of bone fractures are two of the main aspects of this industrial sector. Many companies all over Europe are actively involved in research and development of new materials and components and are also currently confronted with new legal challenges.

Implants | Permanent or long-term implants that are grafted into the human body are differentiated into medical, plastic and functional implants. These include heart and brain pacemakers, and heart-, cochlea-, retina- and tooth-implants.

Artificial Organs | Replacement of the kidney, lung, heart or other organs where the interaction of blood with materials is of utmost importance.

Cardiovascular Devices | Artificial hearts and arteries, together with diagnostic software and repair apparatuses, represent



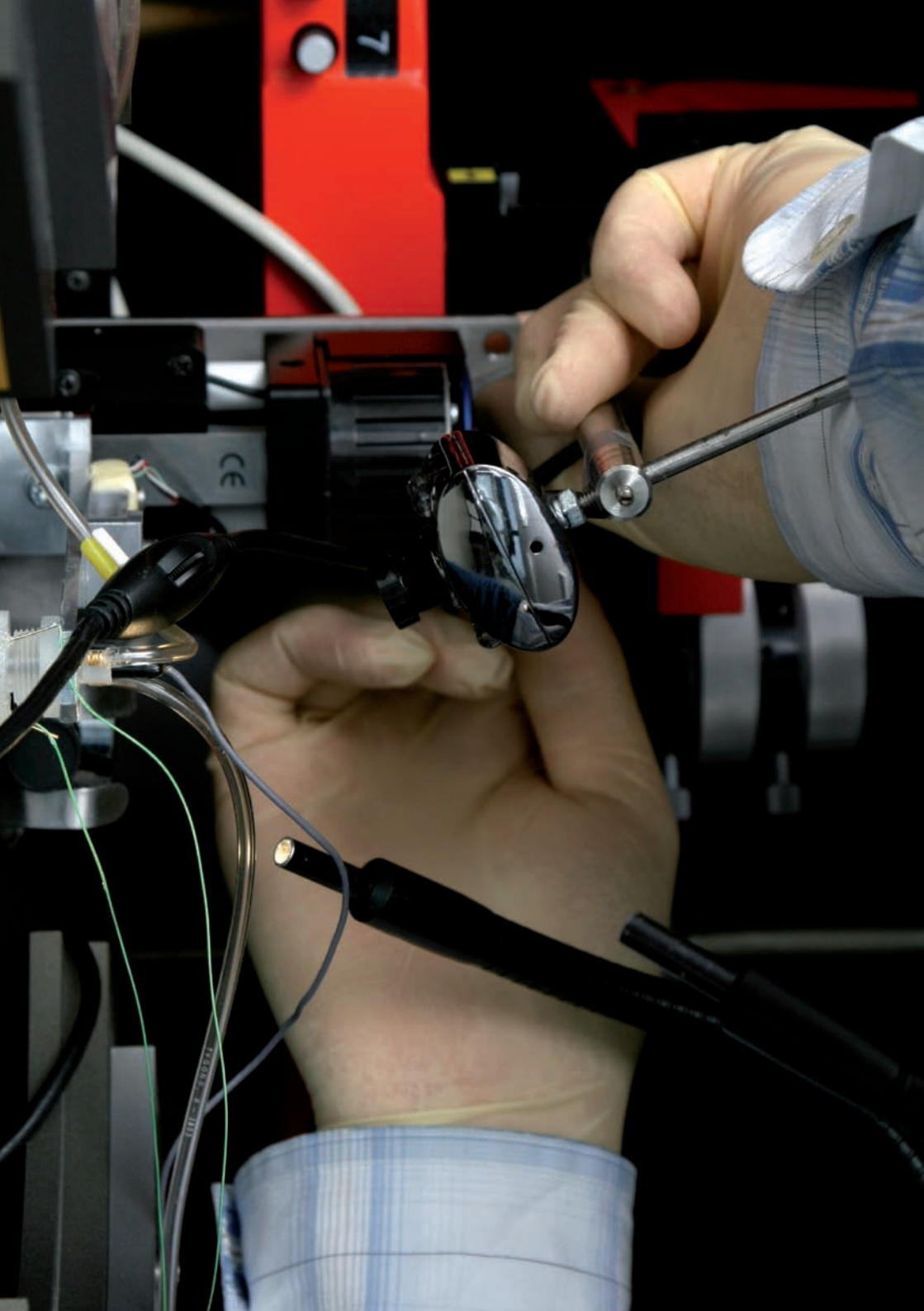
an industrial sector with sales of many million Euros. With the occurrence of heart diseases arterial regeneration is of great benefit in the treatment of human heart disease. Equally complex and ambitious is the support of open-heart surgery.

Tissue Engineering | An interdisciplinary field of research that deals with technologies for growing and cultivating artificial tissues as well as the development of tissue-replacement systems for the substitution of or assistance to tissues and organs, and the development of test systems for drug development.

Diagnostic Devices | Non-invasive examinations are a part of everyday clinical life with x-rays, PET, MRT and ultrasound, all of which are developed by a few key industries. Qualifications in data processing for picture analysis and the accompanying decision-making are the future of this sector.

Robot Surgery | Due to progress in medical image processing it is possible to create a digital 3-dimensional representation of parts of the human body. The use of robotics during surgery is still in its infancy, yet heralds the beginning of a new era in accuracy and efficiency during surgery.

Measurement and Biosensor Technology | The improvement of existing diagnostic methods as well as the contemporary analysis of laboratory values (“point-of-care”) with proximate therapeutic consequences demands intelligent measurement and sensor technology.



Studying Biomedical Engineering

Interconnecting physics, medicine, chemistry, engineering and biology

The main study opportunities for Biomedical Engineering in Germany are offered by the universities of applied sciences. The programs contain a wide spectrum of research and development that ranges from procedure and equipment technology for diagnostics and therapy to analysis, modelling and the simulation of living systems to the development of biomaterials and organ replacement. In the process, biomedical engineering develops solutions for medical requirements exercise and turns them into industrial products. Specializations are also according to the field of study: biomedical engineering, hospital administration and maintenance, medical process technology, dental technology, hearing technology and audiology, and medical physics as well as environmental and hygiene engineering.

At universities biomedical engineering is usually offered as a field of study within physics, electrical engineering or mechanical engineering.

Biomedical Engineering at the FH Aachen, Campus Jülich, offers a comprehensive modern education without an early specialization, thus allowing both broad and long-term, professional prospects, as well as opportunities at the junctions to neighboring disciplines, many of which are also available at the FH Aachen or the nearby Research Centre Jülich.

Research

Lost skills and sensory performance can be reconstructed by developing innovative prostheses. Research in the field of biomedical engineering develops new solutions in complex medical and technical fields. Today, the visible results of minimal invasive surgery, in which miniaturized treatment and surgery procedures revolutionized the diagnosis and the therapy of disease, show the possibilities of biomedical engineering for health care. Sensor chips expand diagnostic possibilities during the supervision of diseases.

Biomedical-technical research can either be fundamental scientific-technical research with adaptability to medicine or fundamental medical research with direct reference to a product by progress research or technical product design. Biomedical Engineering is a subarea with an above-average component of research: the branch average for research and development is approximately 9% of the transaction volume; 15% of the employees are researchers. German companies hold the second highest number of patents (after American companies) and make 50% of their profit on products which have been on the market for less than two years.

Biomedical research at FH Aachen, Campus Jülich, is conducted with extraordinary success and is partly clustered in the competence center Bio- Engineering, and within two scientific institutes: the Institute for Nano and Biotechnology and the Institut for Bio-Engineering. Beyond that there are many research activities reaching across several departments as well as close collaboration with industry and research groups at the Research Centre Jülich. Qualified students regularly participate in these projects during their Master's research. Other students complete their theses in industry or clinics in order to meet prospective employers. Thus, our students are part of up-to date research in the field.

Statistics about studies in Biomedical Engineering that have been supported by public funding:

Employment Market

Well-educated biomedical engineers are required all over the world

The biomedical engineering industry continues to be a strongly expanding growth market, currently worth approximately 100 billion euros worldwide. In the past few years the subsector biomedical engineering has grown twice as fast as the entire industrial sector. German biomedical engineering is traditionally highly in line with the international markets: over 50% of the products are exported. The member states of the EU are the principal customers. Germany is the third largest producer of biomedical technology worldwide, after the USA and Japan, and is in second place in the share of global trade.

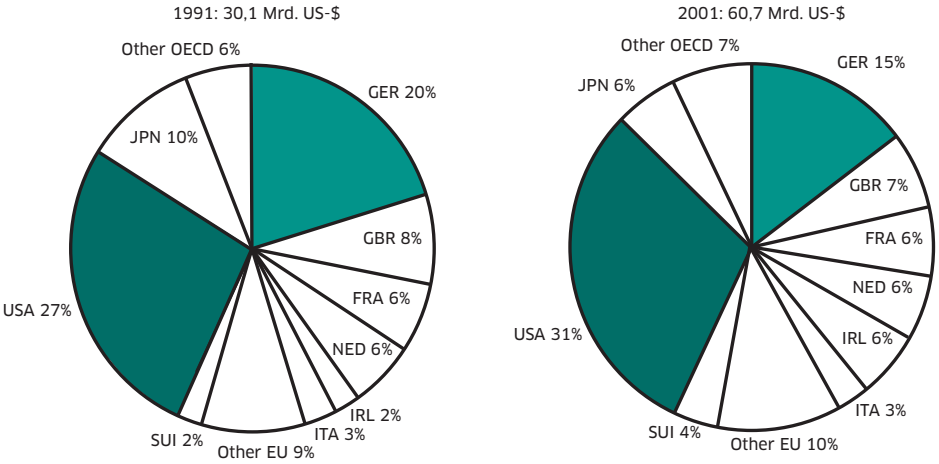
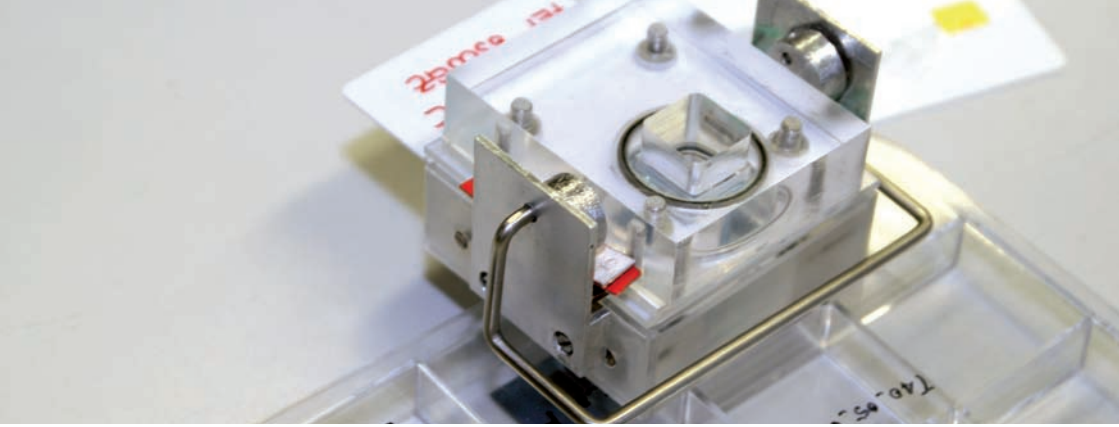


Figure 2: International comparison of global trade shares from 1991 until 2001 for medical-technical products.



Most of the approximately 1,300 companies are middle-class manufacturers with an average of 80 employees. This sector offers great opportunities for a lucrative career with corporate ideas. Students with enthusiasm and a reliable technical background can use biomedical engineering to offer more than just basic health care and exert direct influence on the health of people worldwide.

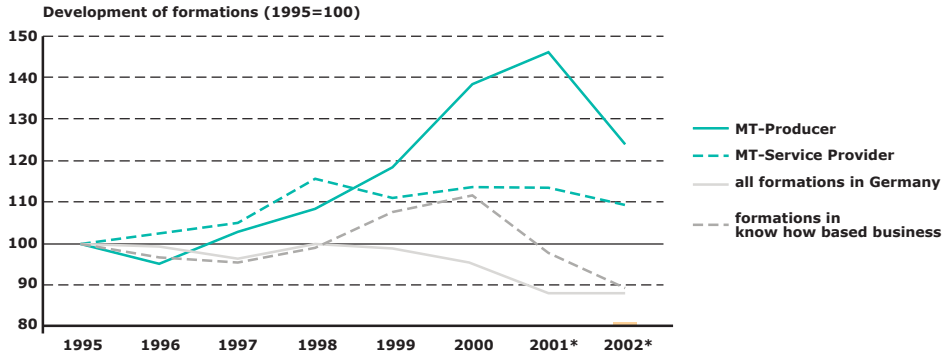


Figure 3: Creation of companies in medical engineering in biomedical engineering compared to the total number of new companies and the number of new companies in science-based branches of industry in Germany from 1995 – 2002.

MT-producer | Establishment of new companies with research and production of medical technical products

MT-service providers | Establishment of new companies with services in medical engineering (offer repair, maintenance, consulting, planning and so forth, develop software for medical applications or operate in the field of health and telemedicine)

Know-how based business | Establishment of new companies is industry with intensive research as well as technology oriented services and science oriented consulting.

Biomedical Engineering is the third most important driver of innovation | Germany / and Europe operate far ahead of the USA and will maintain their lead in the future. According to expert assessments, Asia will be unable to gain a significant share of the market in this segment.

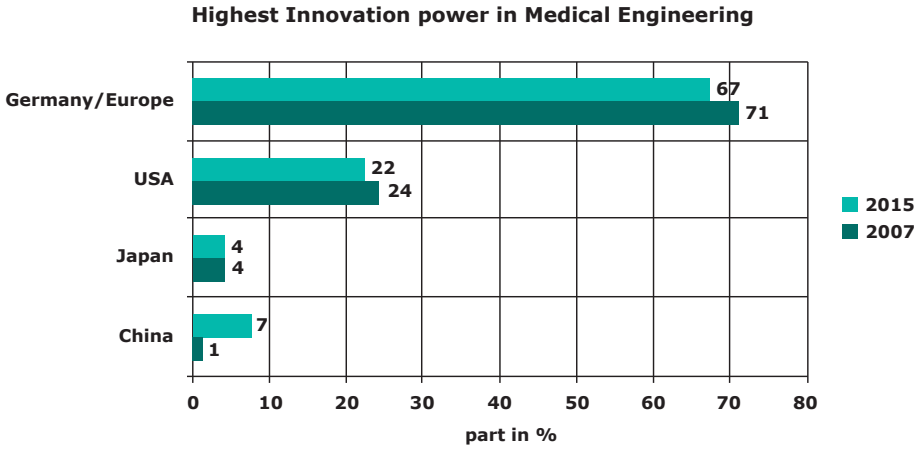
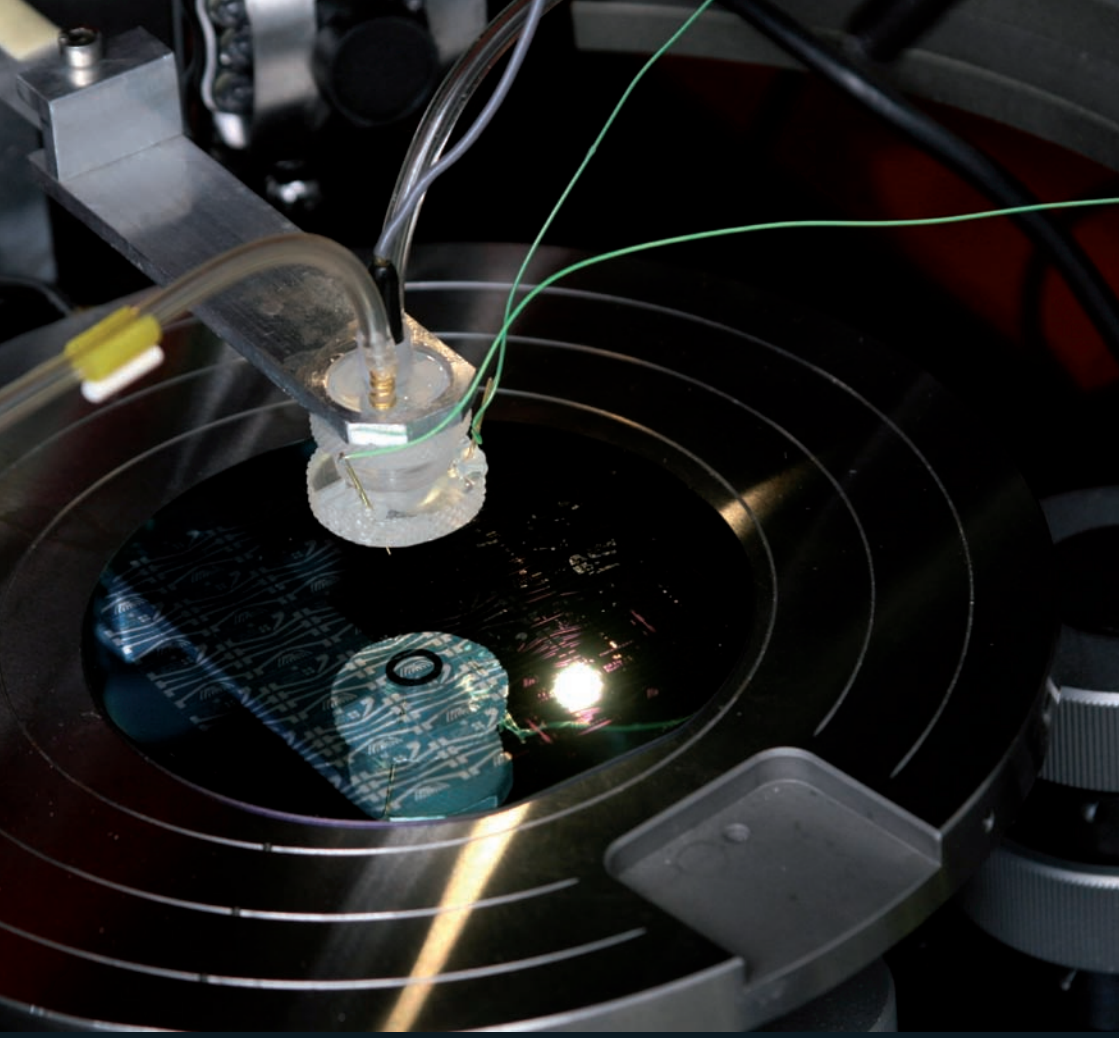


Figure 4: Source: VDE-Innovation Monitor 2007 - Trend in the electro and information technology. VDE, Frankfurt, April 2007.

Salaries and Career Prospects

Biomedical Engineers with experience in clinical fields can find highly paid positions within medical technical companies as engineers, consultants, in design offices or as managers. Biomedical Engineers work predominantly in the medical technical industry, in hospitals, sanatoriums, in doctor's offices and laboratories. In addition to this, there are positions in manufacturing analytical devices, with testing laboratories, governmental institutions, universities and in research. Qualified engineers with good language skills work all over the world.



Before you start

Application Requirements

Applicants with a Bachelor's or equivalent degree (e.g. German Dipl.-Ing.) from a recognized university are invited to apply to the Master's program.

Candidates with a Bachelor or similar degree in the field of biomedical engineering are ranked first. Holders of degrees in other fields closely related to biomedical engineering (e.g. medical technology, biotechnology, mechanical engineering, electronics & communication, electronics & instrumentation, electrical engineering & electronics, medicine) are also well-placed to gain admission to the Master's program.

Your undergraduate background should include a sound knowledge of mathematics beyond calculus, including differential equations, complex variables, linear algebra and probability or statistics, especially for applicants who already have a medical degree. In addition, a sound knowledge of physics (including thermodynamics, modern physics, nuclear physics, electromagnetic field theory) is required. Additional subjects for a successful application are applied mechanics, electrical engineering, electronics, instrumentation, measurement & control and informatics.

The M.Sc. in Biomedical Engineering course is of special interest to students from foreign countries, in particular from Eastern Europe, the new EU countries and developing countries. Because the course is attended by students of different nationalities, lectures are held in English. Therefore a thorough knowledge of English is required (see below).

Students who have taken a national aptitude test in their country or GRE are requested to submit their score.

We are happy to receive your application, however, admission is competitive. The decision to admit a particular applicant will depend to a large extent on the subjects from the applicant's undergraduate studies, which will be compared with the undergraduate program at the FH Aachen (University of Applied Sciences), Campus Jülich.

Language Requirements

English | As the classes are taught in English, fluency in both written and spoken are necessary. The following minimum scores are required:

- TOEFL score 520 on the paper-based test
- TOEFL score 190 on the computer-based test
- TOEFL score 68 on the internet-based test (our TOEFL code number is 9023)
- IELTS Band 5.5
- Native speaker from one of the following countries: Australia, Canada, Ireland, New Zealand, United Kingdom, United States of America.
- German Abitur “Englischleistungskurs” Minimum mark 3 (befriedigend) or German Fachhochschulreife with other English language skills: Minimum mark 3

German | Knowledge of the German language at the extent of the “Zertifikat Deutsch” must be demonstrated by the examination period for modules in the third semester.

Curriculum

No.	Name of module	Cr
Intergative adjustment modules in summer term		
91241	Anatomy	5
91242	Physiology	5
91231	Cell Biology	5
91232	Chemistry / Biochemistry	5
91261	Electrical Engineering	5
91263	Fluid Dynamics	5
91221	Mechanics	5
91262	Medical Mearsurement	5
91270	Written Project 1-5	max.25
	Mobility Period	max.25

No.	Name of module	Cr
Intergative adjustment modules in winter term		
91263	Fluid Dynamics	5
91270	Written Project 1-5	max.25
	Mobility Period	max.25

* for students without a degree in Biomedical Engineering
** for students with a degree in Biomedical Engineering

Cr: Credits C: Compulsory E: Elective SWS: Contact hours per week
L: Lecture T: Tutorial Lab: Laboratory SU: Seminar

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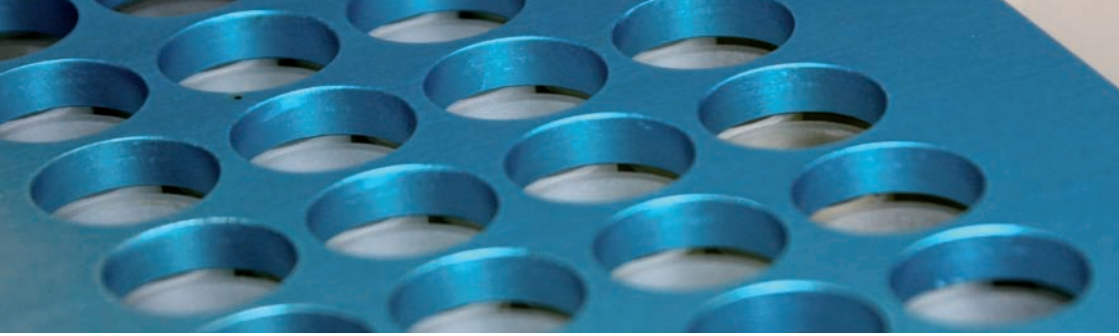
No.	Name of module	Cr
Elective modules in winter term		
92500	Artificial Organs 1	5
92510	Biosensors / Chemical Sensors	5
92520	Cardiovascular Mechanics	2,5
93560	Extracorporal Fluid Mechanics	2,5
92530	Cellular and Molecular Biophysics 1	5
91280	German	5
93590	Material Science and Biocompatibility	5
92560	Medical Imageing	5
92570	Medical Statistics	5
92620	Medical Physics and Medical Imaging Technology	5
92580	Research Planning & Scientific Writing	2,5

No.	Name of module	Cr
Elective modules in sommer term		
93500	Artificial Organs 2	5
93670	Biomaterials / Biocompatibility	5
93520	Biomechanics	2,5
93540	Cellular and Molecular Biophysics 2	5
93550	Dynamic Systems and Computer Modeling	5
93680	Engineering of Bioactive Surfaces (Univ. Hasselt, Belgium)	5
93570	Finite Elemente Method	5
93640	Integrated Circuit Design	5
92550	Laser Applications in Medicine and Biology	2,5
93580	Laser Technology	2,5
93600	Molecular Biology and Genetics	2,5

Cr: Credits
L: Lecture
C: Compulsory
T: Tutorial
E: Elective
Lab: Laboratory
SWS: Contact hours per week
SU: Seminar



No.	Name of module	Sem.	Cr
Catalogue A: Optional modules with 2.5 Credits			
93530	Cell Culture Technology (Basics)	SS	2,5
92602	Radiation	SS	2,5
93690	Microscopy	WS	2,5
34102	Zellkulturtechnik	WS	2,5
93710	Biomedical Applications of Nuclear Technology	WS	2,5

No.	Name of module	Sem.	Cr
Catalogue B: Optional modules with 5 Credits			
93630	Introduction into Information Processing 2	SS	5
93620	Electrophysiology, Electromedicine	SS	5
92540	Continuum Mechanics	WS	5
93280	German (advanced level)	WS	5
92590	Regenerative Medicine	WS	5

Cr: Credits
L: Lecture
C: Compulsory
T: Tutorial
E: Elective
Lab: Laboratory
SWS: Contact hours per week
SU: Seminar

Compulsory Modules

92500/93500 **5 Credits each**

Artificial Organs 1 & 2 |

1 | Definition of Artifical Organs, Biohybridorgans, Bioartificial Organs and Tissue Engineering. Theoretical background of the extracorporeal circulation. Application of the heart-lung-machine and its disposables. Operating mode and construction of various pump systems and their fluid mechanical and medical relevance. Oxygenators as artificial lungs and their relevance for gas exchange. Mechanical cardiac valves and bioprotheses. Dialyzers and dialysis machines for the excretion of urinary substances and of water. Several blood purification procedures and their theoretical physicochemical backgrounds. Membrane technologies.

2 | Assembly and function of pacemakers and pacemaker electrodes. Imparting practical skills in pacemaker circuitry. Application and indication of several pump systems for assisting the heart: roller pumps, axial pumps, diagonal and centrifugal pumps. Total artificial heart. The artificial liver and its technical possibilities to put it from theory to reality. Growing of artificial blood vessels, heart valves and myocardial tissue. Artificial ear and eye.

92510 **5 Credits**

Biosensors / Chemical Sensors | Introduction: definition of sensors; transduction, biological-chemical Signal in physical measured variableBiomolecules: Enzymes, antibodies/antigenes, DNA, immobilization techniques, interaction between substrates

Electrochemical Sensors | Potentiometry, amperometry, conductometry, basic concepts + theoretical bases, reference electrodes, ISE, ISFET, field effect sensors, pH- and ion-measurement, enzyme-sensors (glucose, lactate, penicillin, etc.), biosensors with higher integrated systems, immune- and DNA-sensors, measurement setups.

Optical sensors | fundamental terms + theoretical bases, extrinsic and intrinsic sensor, optrode, fibre-optic sensor, wave guide, SPR-sensor, color-indicators, fluorescence marker.

Further transducer principles | mass-sensitive devices (Piezo-, SAW- effect), arrays, thermal sensors (calorimetry), magnetic sensors.

Manufacturing techniques of sensors: thin film technology, thick film technology, silicon technology, sensor encapsulation and sensor contacting

92520 **2,5 Credits**

Cardiovascular Mechanics | Euler-, Poiseuille-, Womersly formula; Reynolds number. Pressure-volume loop of the left ventricle.
Cardiac output and ejection fraction. Preload, afterload. Isovolumetric relaxation. Structure of the ventricular myocard, myocardial septum and the vascular wall. Pulse rate, arterial compliance, Young's modulus, peripheral resistance. Measuring methods for pressure, flow and geometry. Invasive and non-invasive tonometer. Modelling.

92530/93540 **5 Credits each**

Cellular and Molecular Biophysics I & II |
1 | Introduction to Cellular Engineering, Plasma Membranes of Cells, Membrane Proteins and Functions, Biophysics of Red Blood Cells (Basics, Experiments, Instrumentation), Extra cellular Matrix and Connective Tissue, Cell Junctions in Epithelial Cells, Tissue- and Endothelial Cell Monolayer Permeability, Sensing Cellular Forces, Protein Folding, Protein Cleavage, Transport of Ions and Molecules through the Cell Membrane, Diffusion and Facilitated Diffusion, Active Transport, Osmotic Pressure, Osmosis.
2 | Introduction to Cellular Engineering, Plasma Membranes of Cells, Membrane Proteins and Functions, Biophysics of Red Blood Cells (Basics, Experiments, Instrumentation), Extracellular Matrix and Connective Tissue, Cell Junctions in Epithelial Cells, Tissue- and Endothelial Cell Monolayer Permeability, Sensing Cellular Forces.

92540 **2,5 Credits**

Continuum Mechanics | One-dimensional continuum mechanics: Euler- and Lagrange-coordinates, conservation laws, constitutive equations of simple materials.
Introduction of Cartesian tensor algebra and tensor calculus.
Three-dimensional continuum mechanics: Euler- and Lagrange- specification, constitutive equations of simple materials, conservation laws.

92550, 93580 **each 2,5 Credits**

Laser Applications in Medicine & Biology / Laser Technology |
1 | Energy levels of atoms and molecules, interaction of light and matter, laser resonators and laser beams, interaction of laser radiation and tissue, Nd:YAG lasers, CO2 lasers, details of laser-tissue interaction, optical fibers, excimer lasers, semiconductor lasers, photorefractive eye surgery: PRK and LASIK, confocal microscopy, microstructuring with lasers, photodynamic therapy, fluorescence and light detection.
2 | Basic physics of lasers and laser beams, special laser types, interaction of laser radiation and biological tissue, technical details of medical laser systems, selected topics of laser applications, laser safety, laser applications in biological and medical laboratories, fluorescence techniques.

92560 **5 Credits**

Medical Imaging | Medical imaging Acquisition Systems and their diagnostic and system typical visual contents. Theory of Image Digitisation (raster, quantification, loss of information). Basics of medical image processing: Grey-Level Level Operations, Image Subtraction, -Averaging, Image Filtering (in spatial domain), Analysis of image quality (MTF, image noise, S/N-bahvior), Frequency Domain & Image-Restorations, image segmentation, Three-Dimensional - Visualization of medical volume data, Image Compression (JPEG-, Wavelet-method, PACS (Picture

Archiving and Communication Systems). Imaging diagnostics in telemedicine.

92570 **5 Credits**

Medical Statistics | Basics of probability calculus

- Probability, random variable, independence
- Distribution function, quantile, power moment
- Special discrete and continuous distribution
- Statistics
- Basics of theory of estimation
- Maximum-likelihood procedure for parameter estimation
- Exact and asymptotic confidence intervals
- Basics of test theory
- Parameter test and test of goodness of fit
- Introduction to variance analysis
- Introduction to regression analysis
- Introduction to durability analysis

92580 **2,5 Credits**

Research Planning and Scientific Writing | What is research? How do we find an original topic? Data bases on the internet. How to use a library? How do we plan a research project and how do we defend it? Several examples. What is a scientific journal? What is Science citation index and the impact factor of a journal? What should we pay attention to while presenting our data at the meetings? How should we write our paper and how do we submit it?

93520 **2,5 Credits**

Biomechanics | In the beginning the important basics of continuum mechanics (stress, strain, constitutive laws) as well as the basics of finite-elements-method will be introduced and will be illustrated by means of several examples from the field of biomechanics. Using the example of a total endoprosthesis of the hip the modus operandi of modeling a tangible biomechanical problem will be introduced along with the mechanical illustration of muscular strengths and joints (boundary condition). In the process clinically relevant questions (manner of prosthesis fixation, prosthesis material etc.) will be especially addressed as well as possible sources of error which can result from simulation. The mechanical description of growth processes (bone remodeling respectively bone conformation) will be discussed in detail during lecture. In order to understand the experimental processes of biomechanics the procedure of measurements of relevant mechanical variables will be reviewed. Applicable methods for acquisition of momentum, force and deformation values will be explained. Furthermore the generation of force and displacement variables for experimental studies will be addressed. In the process general basics will first be created and subsequently be studied in more detail by using case studies. The importance of determining parameters for mechanical simulation will be analyzed and pinpointed by examples and experimental setups. Besides the necessary theoretical aspects experimental setups especially in the field of implant testing and biomaterial testing will be analyzed.

93530 **2,5 Credits**

Cell Culture Technology | General Biotechnology | Overview of products and applications of modern biotechnology

Cell lines | establishment, characterization, cultivation: Distinction between finite and continuous cell lines, transformation, methods of cell cultivation, ingredients of culture media, cell culture safety considerations, special methods of cell cultures.

Cell culture-bioreactors | Scale up of cell culture reactors, roller flasks, microcarrier, fluidized-bed reactors, fixed-bed reactors etc.; fermentation by batch, fed-batch and continuous operation, methods of "Zellrückhaltung"
Products of cell culture technology | vaccines: pharmaceutical proteins (Factor VIII, t-PA, EPO, GM-CSF), glycosylation of proteins (structure, importance), monoclonal antibodies: structure, preparation through hybridoma technology, humanized antibodies, diagnostic application of antibodies (ELISA; Immunohistochemistry, Tumorimaging), therapeutic application of antibodies (examples of agents), application of antibodies for purification of proteins and cells
Cellular therapies | application of human cells, e.g. hematopoietic stem and precursor cells, T-cells, dendritic cells, for therapy e.g. of tumors; the term stem cells; embryonic and adult stem cells
Gene therapy | Use of genetically modified human cells, introduction of experimental approaches, e.g. for tumor treatment, HIV among other things, reference to Biomedical engineering and practical relevance: manufacturing of pharmaceutical products, diagnostics, therapy with hematopoietic cells.

93550 **5 Credits**

Dynamic Systems a. Computer Modelling | Presentation of dynamic systems, classification and description of system elements, experimental determination of dynamic systems, theoretical descriptions of dynamic systems (mathematical modeling), influence of dynamic systems by feedback control systems, stability of dynamic systems, optimization of dynamic systems.

93670 **5 Credits**

Biomaterials/Biocompatibility | A general introduction into the field of biomaterials. From synthetic organic, inorganic and natural materials to the point of composite materials. The biocompatibility of materials to several tissues and organs of the human body will be described. The method of biological decomposability of biomaterials will be discussed. Afterwards a listing of the versatile fields of application of biomaterials for the manufacture of implants or artificial organs, as well as the possibility of timing medicine dispensing inside the human body will follow.

93560 **2,5 Credits**

Extracorporeal Fluid Mechanics | Mechanical and flow mechanical control mechanisms during filling and depletion processes of the heart, both the atria and the ventricles. Flow mechanical aspects of cardiac contraction, the blood vessels and vessel motor function.
Application of complex flow mechanical correlations in extracorporeal flows, e.g. in catheters, cannulas, blood pumps, dialyzers, oxygenators, heart-lung-machines as well as heart valves and models of blood vessels, etc. Consideration of biological and medical aspects of extracorporeal circulation. Modeling. Application of vascular tree models, lumped parameter models. Simple application of simulation techniques (MatLab, Simulink).

93570 **2,5 Credits**

Finite Element Method |
One-dimensional problems | spring, bar and beam elements.
Two-dimensional problems | linear elasticity theory, disc, plate and shell elements.
Three-dimensional problems | linear elasticity theory, continuum elements.

Modeling and solution | symmetry, equation solvers, errors and convergence.
Dynamic problems | vibrations.
Thermal problems | temperature and stress fields.

93600 **5 Credits**

Molecular Biology and Genetics |
The lectures are arranged under four subject areas: (a) DNA and RNA structure and manipulation of genetic material, (b) replication of DNA, (c) transcription and its regulation, and (d) translation of genetic information into proteins. Whenever possible it will be tried to illustrate how these basic themes relate to molecular biology in Medicine, Law and Biotechnology. The course will begin with consideration of the biochemical basis of heredity as seen through the structure of DNA and RNA. This section will emphasize DNA structure and function. Discussion of DNA as a double-stranded molecule will explore base pairing, denaturation, renaturation, and hybridization analysis. A discussion of the basic nucleic acid biochemistry to an analysis of genomic structure will be included. Transfer of information contained in DNA structure to a cellular action or process is expressed through intermediate molecules: mRNA. In addition to the biochemistry and enzymology of transcription and RNA structure, considerable attention will be focused on regulation of gene expression. Mechanism of transmission of information contained in the DNA structure through RNA, and its final expression as functional protein. Practical training: SDS Page Electrophoresis and image analysis, Western Blotting, Total RNA extraction, cDNA, Real Time PCR.

93640 **2,5 Credits**

Integrated Circuit Design | The student should be able to do an integrated circuit design (elementary digital circuits on FPGAs) from functional idea to the tested circuit.

- Revisit of digital systems fundamentals,
- Classification of integrated circuits,
- Design flow and EDA tools,
- The different design views,
- Structures and properties of MOS circuits,
- Elementary digital circuits an different MOS technologies,
- Full custom design of simple digital circuits,
- Design rules, scaling theory,
- Circuit description using VHDL,
- Synthesis of digital circuits,
- Testing of integrated circuits.

General Information

Organisational Matters

Programme duration, commencement of study and course structure | Programmes at the University of Applied Sciences Aachen are offered in modules and ECTS-credit points are awarded. Including the Masters' thesis, the standard length of the programme is two years (four semesters) or 120 ECTS-points. Lectures are held in English.

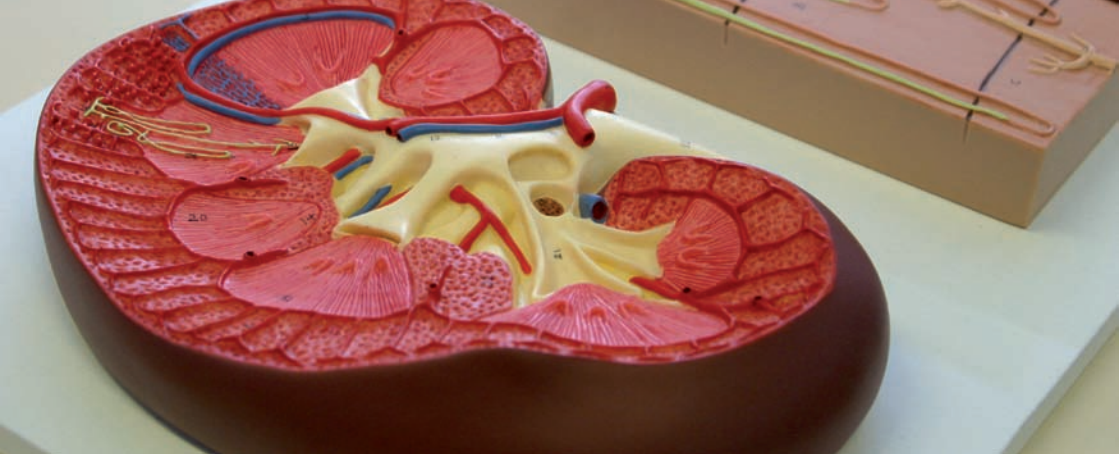
Admission for international Bachelor graduates and national graduates without a Bachelors degree in Biomedical Engineeirng is only possible in the summer semester. For students with a degree in Biomedical Engineering it is also possible to be admitted in the winter semester.

Fees and the cost of the programme | Every semester all students must pay a social contribution to the Studentenwerk (Student services) and a student contribution to the work of the ASTA (General Student's Committee). These include the semester ticket of the ASEAG (Aachen Public Transportation Association). The amount is determined each semester. The listing of each of the current fees can be checked at:
www.fh-aachen.de/sozialbeitrag.html

The fees were 199.00 Euros in the winter term 2009/2010. Starting in the winter semester of 2011 the Land Government North-Rhine Westphalia refrains from charging additional study fees.

Application Documents | All documents must be in English or German or must be accompanied by certified translations into English or German. The following documents must be attached to the official application form:

- C.V. (curriculum vitae)
- All university transcripts and degrees
- Proof of English language requirement



> Statement of motivation

Important: Applications will only be considered if all prerequisites are fulfilled and all documents were notarized by a notary or the German embassy. We cannot consider documents that have been stamped by a school, or faxes, e-mails or uncertified photocopies and illegible copies.

Application Fee | There is no application fee at this time.

Confirmation of Receipt of Application and Admission | We will send you an e-mail with an application number when we receive your application. You must use your application number in all correspondence with us. In most cases you will receive a letter from us by the first week in January regarding your admission status.

Application Deadline | 15 November of each year for the programme starting the following March. **15 June of each year** for the programme starting the following September.

We only take new students in the Masters' Programmes in the summer semester.

Please, send completed applications with all documents, including notarized copies of all certificates to:
FH Aachen, Jülich Campus
Masters Programmes
Heinrich-Mussmann-Straße 1, 52428 Jülich
Germany

For further information
www.fh-aachen.de/master.html


Research
1000

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