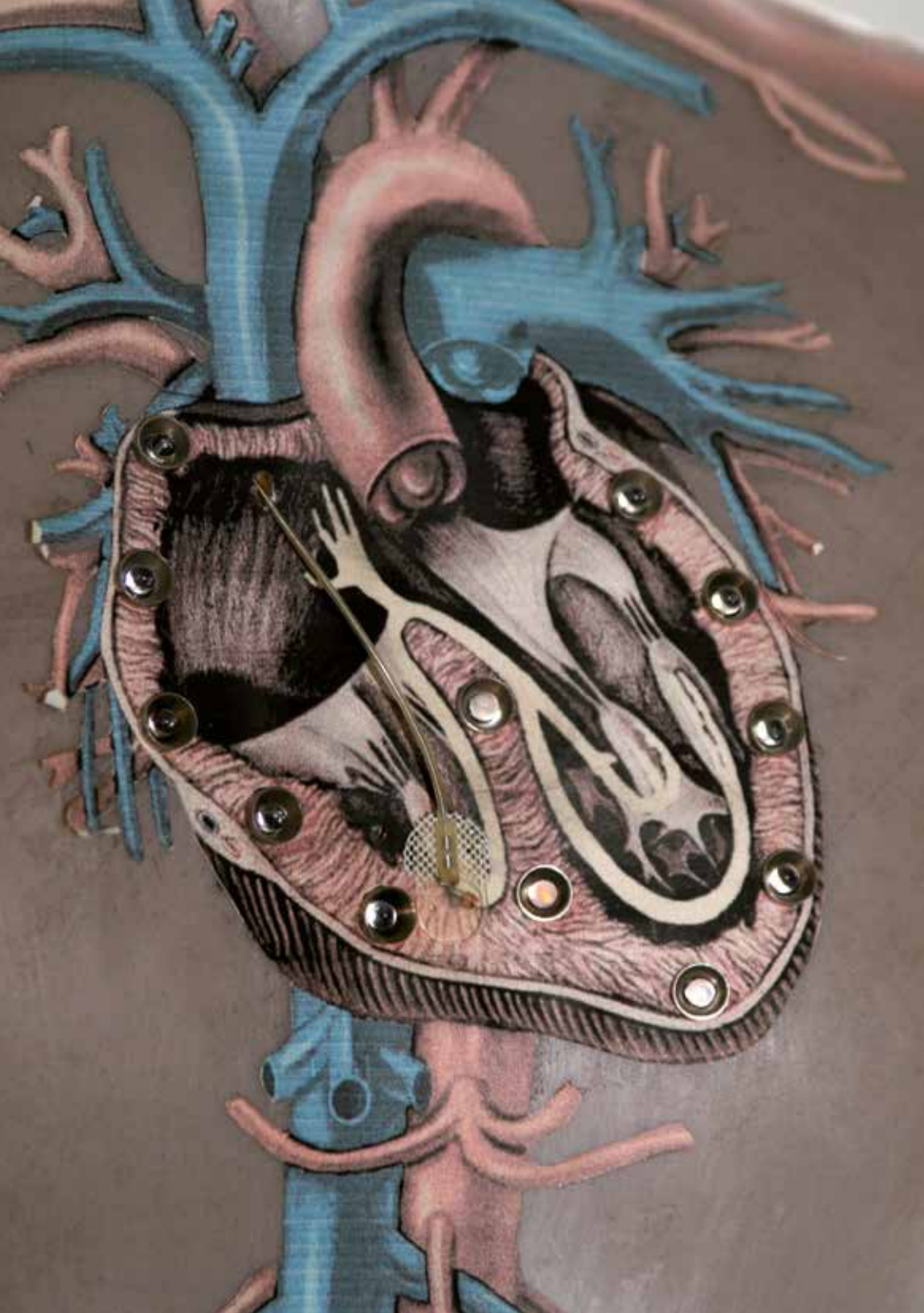




# Biomedical Engineering Master of Science

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FACULTY 09  
MEDICAL ENGINEERING AND TECHNOMATHEMATICS



## Biomedical Engineering

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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 shared 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.

We are looking forward to welcome you as students of the FH Aachen.

Yours sincerely,  
Prof. Dr. rer. nat. Christof Schelthoff  
Dean, Faculty of Medical Engineering and Technomathematics



# 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 technization 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.

**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, orthoses, 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?



© FH Aachen, Jeanne Niermann

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:

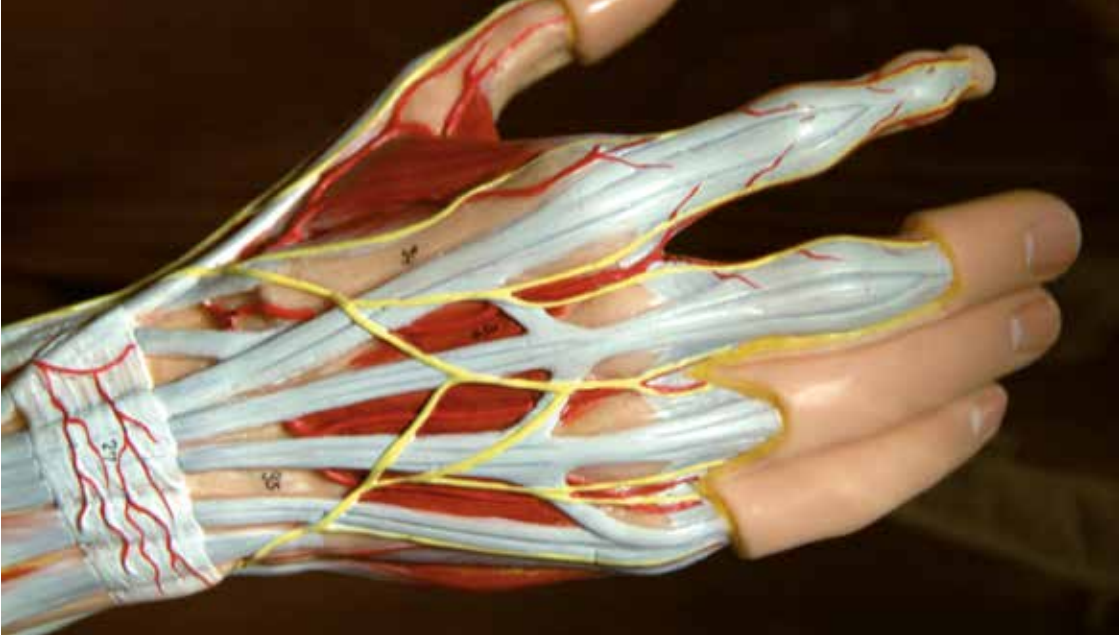
**Artificial Limbs** | replacement of parts of the upper and lower limbs that were damaged by illness or trauma. Engineers in this field work for numerous European manufacturers.

**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.

**Medical Devices** | Design, development and construction of medical devices in an interdisciplinary team, merging medical needs with engineering requirements.

**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



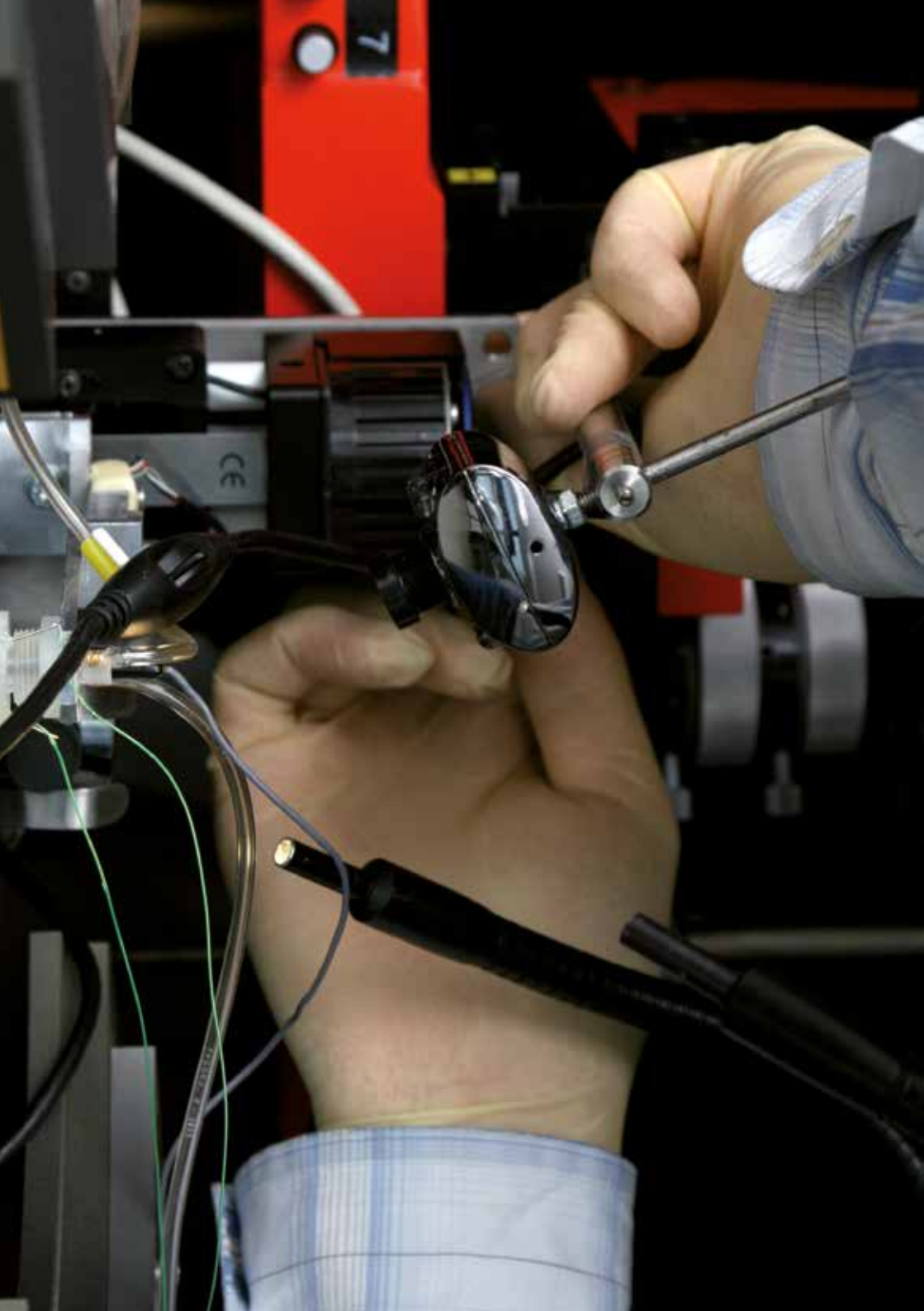
benefit in the treatment of human heart disease. Equally complex and ambitious is the support of open-heart surgery.

**Tissue Engineering & Artificial Organs** | An interdisciplinary field of research that deals with technologies for growing and cultivating artificial tissues as well as the development of tissue-replacement routines. Support of organs where the interaction of blood with materials is of utmost importance.

**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. 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 Bioengineering, 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.

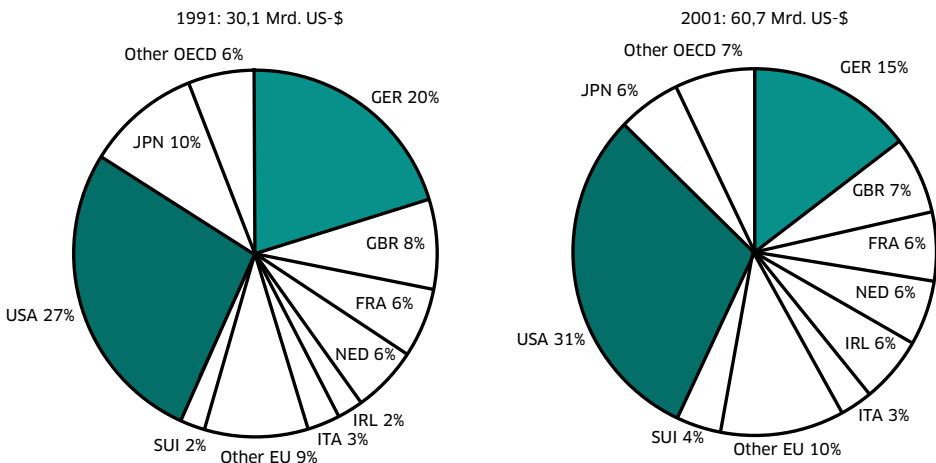
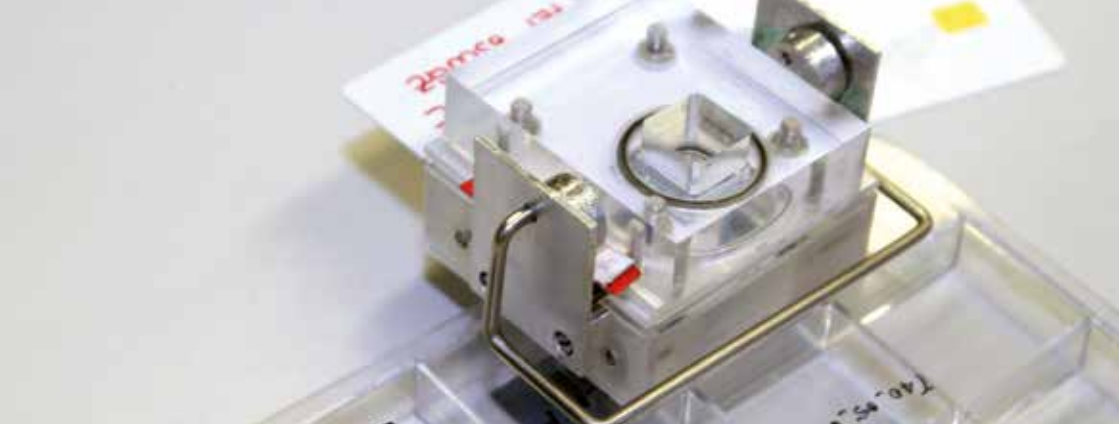


Figure 1: International comparison of global trade shares from 1991 until 2001 for medical-technical products.



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.

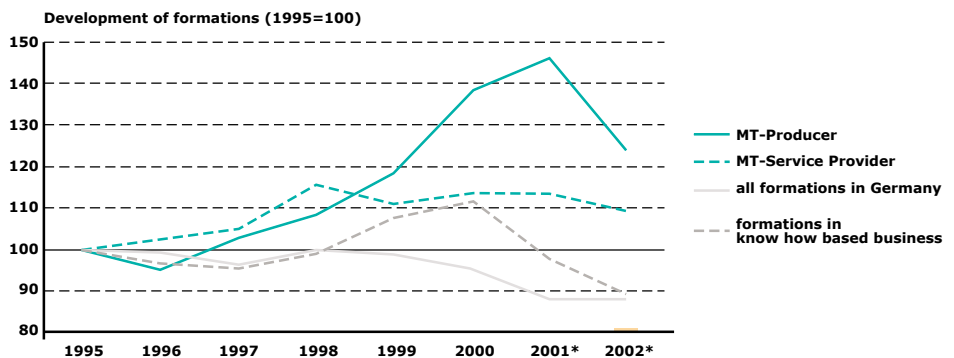


Figure 2: Creation of companies in medical engineering in biomedical engineering compared to the total number of new companies and the number of new companies in science-based branches of industry in Germany from 1995 - 2002.

**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.

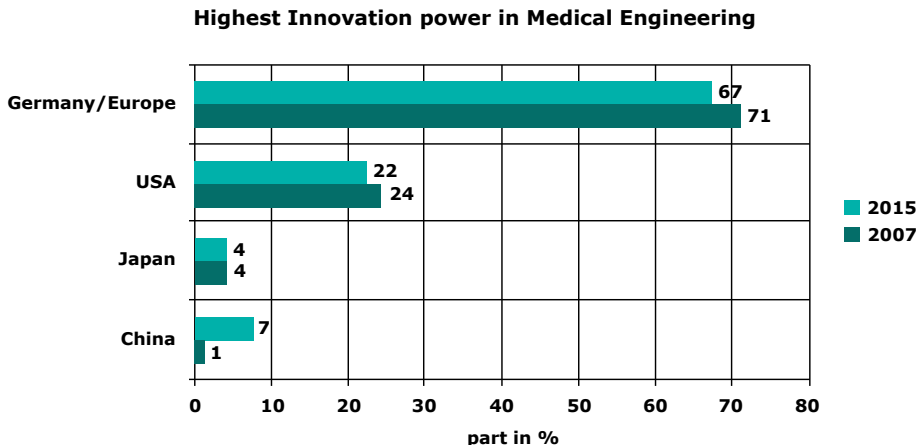
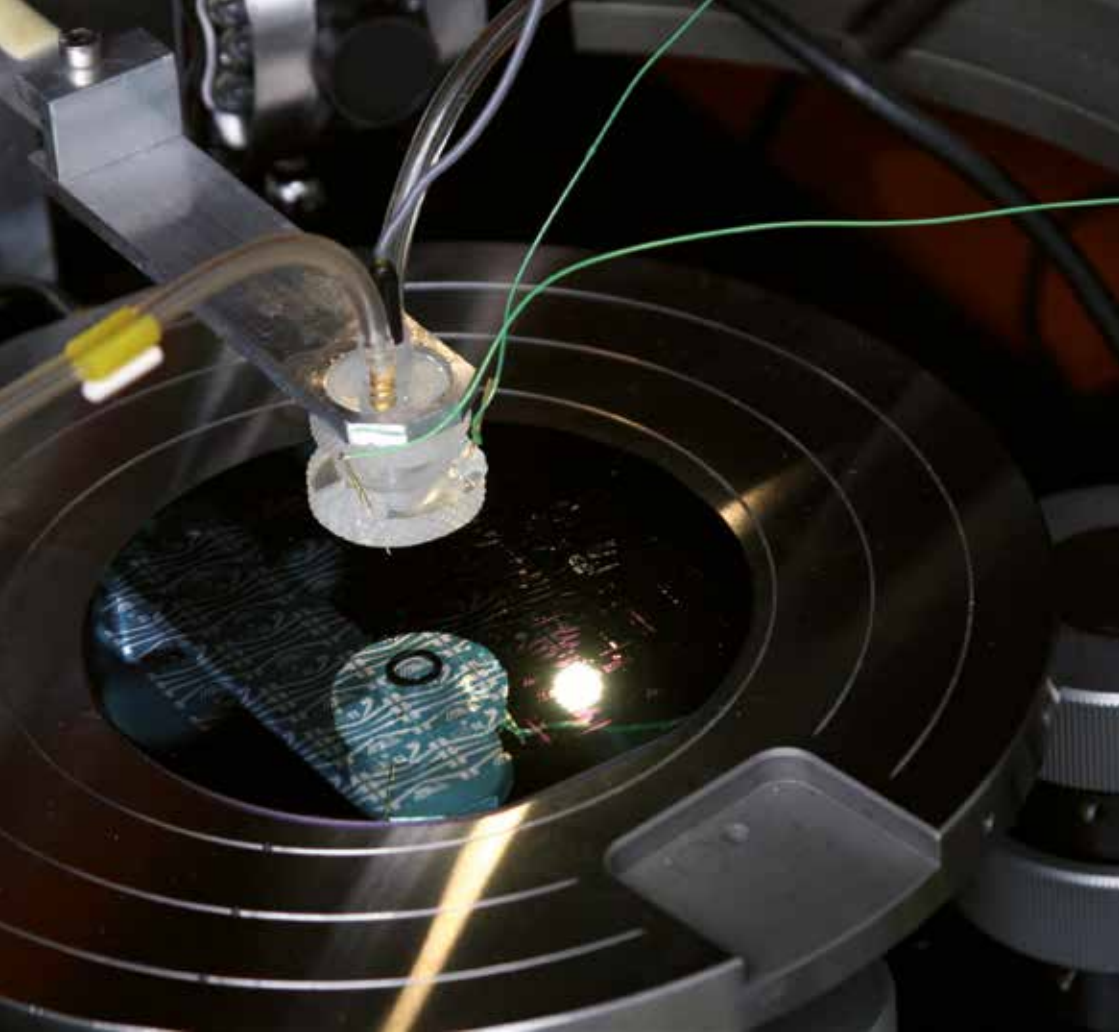


Figure 3: Source: VDE-Innovation Monitor 2007 - Trend in the electro and information technology. VDE, Frankfurt, April 2007.

# 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



# Admission 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, mechanical engineering, electronics & communication, electronics & instrumentation, electrical engineering & electronics, biology, 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 international students, because the course is attended by students of different nationalities, lectures are held in English. Therefore excellent knowledge of English is required (see below).

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, both written and spoken fluency is necessary. The following minimum scores are required:

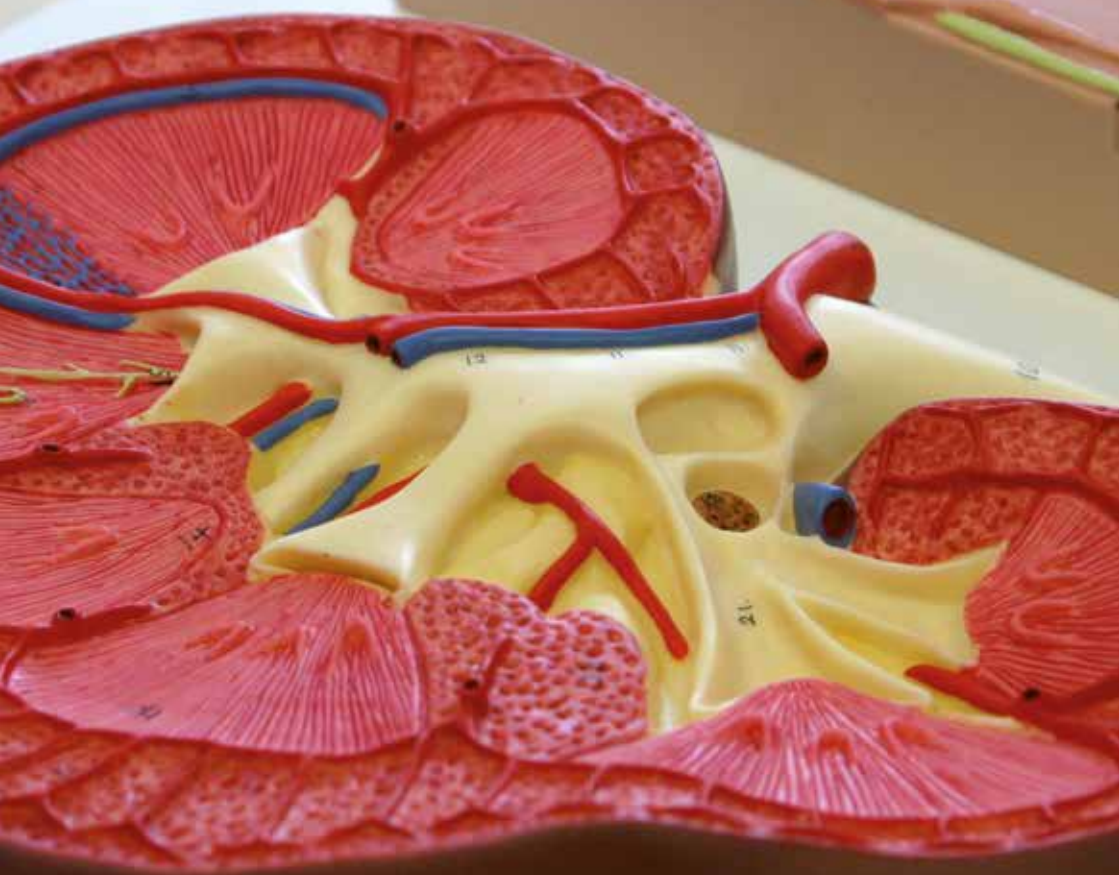
- > TOEFL internet-based test score 68
- > IELTS Band 5.5

This test is mandatory for all non-native English speakers including for applicants from Bangladesh, Egypt, India, Indonesia, Jordan, Lebanon, Malaysia, Nepal, Pakistan, Syria or the United Arab Emirates. Applicants from these countries **MUST** submit a TOEFL or IELTS score sheet as described above. We cannot make any exceptions.

As native speakers we accept applicants from one of the following countries: Australia, Canada, Ireland, New Zealand, United Kingdom, United States of America. Applicants from other countries with questions please contact the program coordinator at [biomedmaster@fh-aachen.de](mailto:biomedmaster@fh-aachen.de).

Applicants with German Abitur "Englisch" Minimum mark 3 (befriedigend) or German Fachhochschulreife with other English language skills: Minimum mark 3 do not need submit a TOEFL or IELTS score sheet.

**German** | Knowledge of the German language at the level of the "Zertifikat Deutsch" must be demonstrated by the examination registration period for modules offered in the third semester. Applicants with German Abitur or Fachhochschulreife are exempt from these requirements.



# Curriculum

No.	Name of module	Cr
<b>Integrative adjustment modules in summer term</b>		
91000	Materials	5
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

You will find detailed descriptions of the modules on [www.fh-aachen.de/studium/biomedical-engineering-msc/studieninhalte](http://www.fh-aachen.de/studium/biomedical-engineering-msc/studieninhalte).

\* 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



No.	Name of module	Cr
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### Elective modules in winter term

92500	Artificial Organs 1	5
92510	Biosensors / Chemical Sensors	5
92520	Cardiovascular Mechanics	2,5
92530	Cellular and Molecular Biophysics 1	5
92560	Medical Imaging	5
92570	Medical Statistics	5
92620	Medical Physics and Medical Imaging Technology	5
92580	Research Planning & Scientific Writing	2,5
	Forschungspraxis: Leitlinienentwicklung I (deutsch)	5
	Lehr- und Lernmethoden (deutsch)	2,5

### 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
	Forschungspraxis: Leitlinienentwicklung II (deutsch)	5
	Lehr- und Lernmethoden (deutsch)	2,5

No.	Name of module	Sem.	Cr
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**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
	Computational Fluid Dynamics	WS	2,5

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**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
	Dynamic Systems and Computer Modeling	WS	5
	Biomedical Engineering in Ophtalmology	WS	5

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Cr: Credits  
L: Lecture

C: Compulsory  
T: Tutorial

E: Elective  
Lab: Laboratory

SWS: Contact hours per week  
SU: Seminar





General  
Information

# Organisational Matters

## **Program duration, commencement of study and course structure**

| The Master of Science in Biomedical Engineering program is a two years, four semesters course, including the Master's thesis. Student earn a total of 120 ECTS-points. All lectures are hold in English.

International Bachelor graduates and national graduates without a Bachelor degree in Biomedical Engineering can be admitted only in the summer semester. For students with a degree in Biomedical Engineering admission is also possible in the winter semester.

**Fees and the cost of the program** | Tuition is fully subsidized by the German government for excellent international and domestic students. The mandatory semester fee, which is currently approximately € 250 , includes public transportation and other amenities. This may change in future. International students who have been admitted may be required to submit proof to the German embassy that they have approximately € 8100 in order to get a visa to study in Germany.

The mandatory semester fee includes a social contribution to the Studentenwerk, sStudents services, a student contribution to the work of the ASTA, General Student's Committee, the semester ticket for free public transportation within the German state of North-Rhine Westphalia, NRW. The current amount of the fees can be checked seen at [www.studierendensekretariat.fh-aachen.de](http://www.studierendensekretariat.fh-aachen.de)

**Application** | All applications must be submitted online. Informations and the link to the online application portal is available at [www.fh-aachen.de/studium/biomedical-engineering-msc/](http://www.fh-aachen.de/studium/biomedical-engineering-msc/)



All uploaded documents must be in English or German or must be accompanied by certified translators into English or German. The following documents must be submitted online:

- > C. V. curriculum vitae
- > All university transcripts and degrees
- > Proof of English language requirement
- > Final high school certificate

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

**Confirmation of receipt of Application and admission** | Upon completion of the online application, you must print the PDF document generated at the end of the application procedure, sign it, scan it and send it to the given email address printed on the PDF document. Please use your application number in all your correspondences with us. All decisions regarding your application will be posted in the online application portal within 2 month of the application deadline.

**Application deadline** | Please note the varying application deadlines for applicants from within and outside the European Union.

Applicants not from the European Union: 15 November in winter semester for the program starting in the following March. 15 May of each year for the program starting in the following September.

Applicants from the European Union 15 January for the program starting in March and 15 June for the program starting in September.

We only accept online applications

**For application information** | see  
[www.fh-aachen.de/studium/biomedical-engineering-msc](http://www.fh-aachen.de/studium/biomedical-engineering-msc)



# Addresses

## **FH Aachen, Campus Jülich Faculty of Medical Engineering and Technomathematics**

Heinrich-Mußmann-Straße 1  
52428 Jülich  
Germany

### **Dean**

Prof. Dr. Christof Schelthoff  
Phone +49.241.6009 53806  
schelthoff@fh-aachen.de

### **Master Programme Coordinator Biomedical Engineering**

Prof. Dr. Torsten Wagner  
Phone +49.241.6009 53766  
torsten.wagner@fh-aachen.de

### **ECTS-Koordinator**

Prof. Dr. rer. nat Horst Schäfer  
T +49.241.6009 53927  
horst.schaefer@fh-aachen.de

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[www.studienberatung.fh-aachen.de](http://www.studienberatung.fh-aachen.de)

## **Registrar's Office, Jülich Campus**

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52428 Jülich  
P +49.241.6009 53117  
[www.studierendensekretariat.fh-aachen.de](http://www.studierendensekretariat.fh-aachen.de)

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