

BiomaTiCS – Biomaterials, Tissues and Cells in Science

A research focus program of the University Medical Center of the Johannes Gutenberg University Mainz, Germany



UNIVERSITÄTSmedizin.

MAINZ

BioMaTiCS – Biomaterials, Tissues and Cells in Science

Biomaterials – foreign materials that come in contact with the biological tissues of the human body – pervade all aspects of modern medicine, both in preventive and therapeutic healthcare. They play an important role in medical devices, drug delivery systems and diagnostic techniques. In recent years functional replacement of damaged tissues and organs with artificial implants has become a widespread therapeutic option to treat various medical conditions.



Interview with **Prof. Dr. Dr. Bilal Al-Nawas**, Spokesman of BioMaTiCS
Oral and Maxillofacial Surgery, Plastic Operations, University Medical Center of the Johannes Gutenberg University Mainz, Germany

What is - BiomaTiCS?

The research focus program BiomaTiCS of the University Medical Center Mainz works as an interdisciplinary network of materials scientists and medical researchers, who are interested in understanding and modulating the complex interactions between biological systems and artificial as well as biogenic materials.

What is the aim of - BiomaTiCS?

Despite of advancements in material design and surgical techniques, medical device-related clinical problems like inflammation, rejection of implants, foreign body granulomas, excessive scar formation, lack of tissue-adhesion, material degradation, infection and toxicity are very common. BiomaTiCS offers an excellent platform for an exchange of information among competent specialists to combine all their knowledge necessary to tackle these problems.

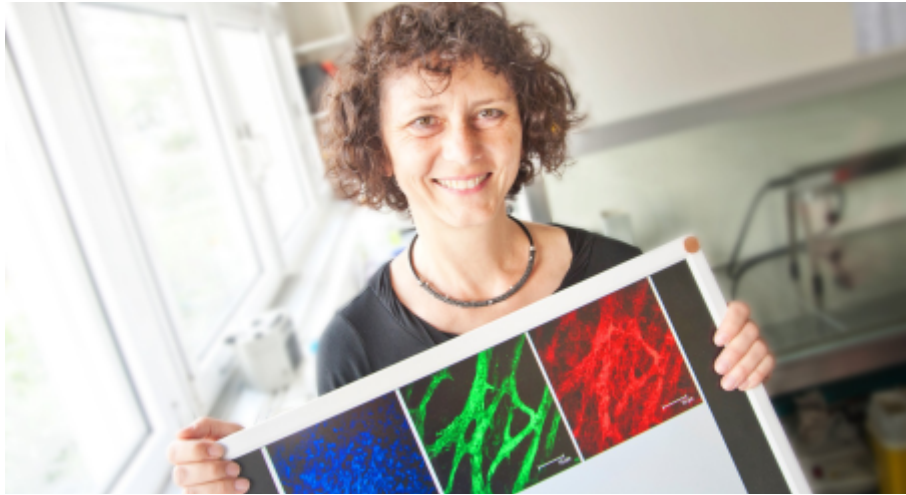
Who is - BiomaTiCS?

Our consortium is characterized by numerous collaborative research projects between various medical disciplines of the University Medical Center Mainz, materials scientists within the Johannes Gutenberg University Mainz and at external research institutes as well as several industrial partners.

The core expertise of the members of the research focus program „BiomaTiCS“ lies in:

- Analyses of the complex interactions between biomaterials and biological systems, from the molecular and subcellular level to full tissue and immune reaction.
- Advancement of understanding the synthesis and behaviour of biocompatible and biomimetic polymers.
- Indication-specific modification of existing and approved implant materials and surfaces for their improvement of their function and durability.

On the following pages the main lead researchers of BiomaTiCS are introduced.

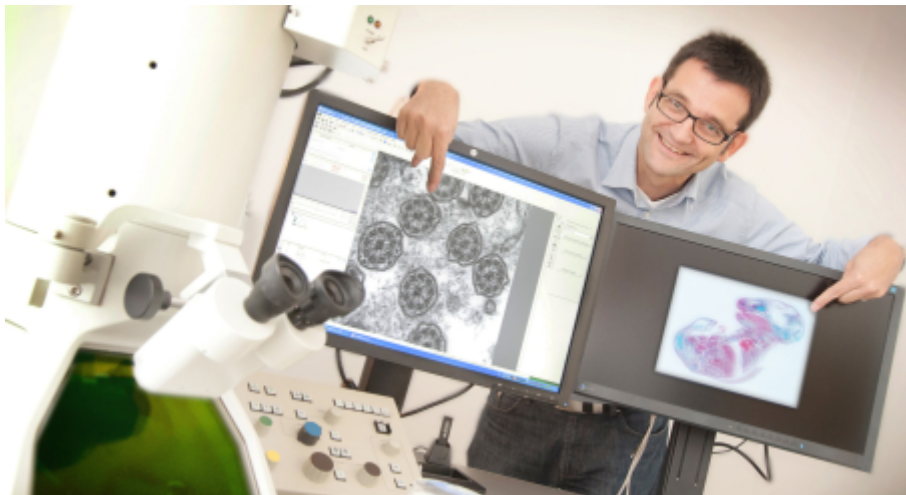


Prof. Dr. Walburgis Brenner of the Department of Urology is working on the development of a pre-vascularized scaffold for use as an oral mucosa equivalent. Oral mucosa has been utilized for urethral reconstruction in cases of hypospadias for more than a decade. The harvesting of large specimens of oral mucosa for the reconstruction of large sections of the urethra is technically challenging and causes great discomfort, pain and secondary scarring to the patient. An alternative technique is found in the construction of a tissue-engineered oral mucosa, composed of a biomatrix seeded with autologous primary cells. In Prof. Brenner's group scaffolds are pre-seeded with fibroblasts and mucosal epithelial cells, building a basement membrane. For better vascularisation, microvascular endothelial cells are added, forming capillary-like structures for better engraftment. In this context, biomatrices of different origin and special modifications are analysed and evaluated.



Prof. Dr. Jürgen Brieger, Department of Otorinolaryngology, Head and Neck Surgery, University Medical Center, Mainz.

“Aim of our research is the targeted modification of material surfaces to improve interface properties of implant materials for better integration and to establish nanoparticles for molecular imaging and drug delivery. Related to these medical applications of metal oxid nanoparticles we analyse the mechanisms of cellular uptake, intracellular transport and potential toxicity to avoid undesired side effects. To reach these aims, we collaborate with several working groups inside and outside of the university medicine and participate in research clusters like the MPGC (Max Plank Graduate center).”

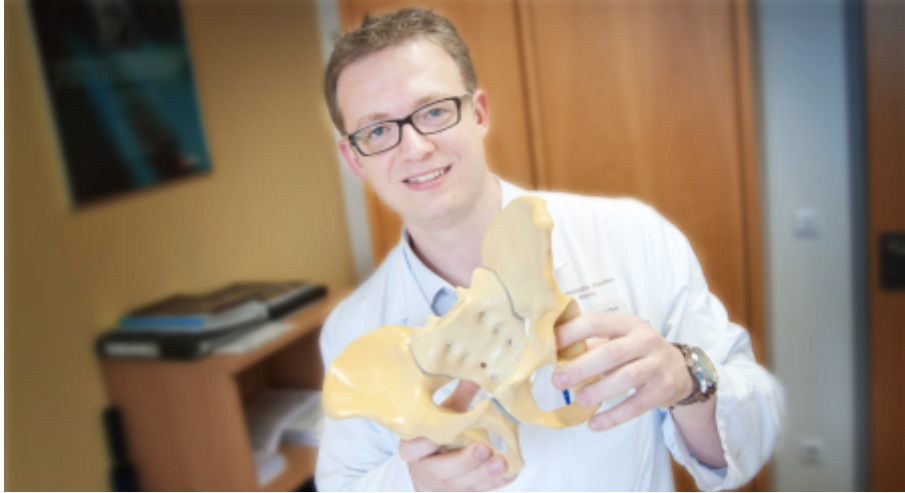


Dr. Christoph Brochhausen-Delius, consultant pathologist, head of the electron microscopy laboratory at the Institute of Pathology and group leader in Tissue Engineering of the REPAIR-lab uses human development as a model for therapeutic strategies based on Tissue Engineering and for Regenerative Medicine. Inspired by human bone development he found a potential candidate molecule to promote chondrocyte proliferation and maturation. With his collaboration partners he was able to establish a delivery system based on these findings, which was integrated in a biomimetic scaffold for use in articular cartilage defects and was then successfully tested in animals. Driven by the fascination of human embryology and its recapitulation in tissue regeneration his group is developing innovative applications, for example, in wound healing, adhesion prevention and the treatment of chest wall deformities. Focused on the life sciences in close cooperation with partners from material science his research has one motto: Learning from nature.

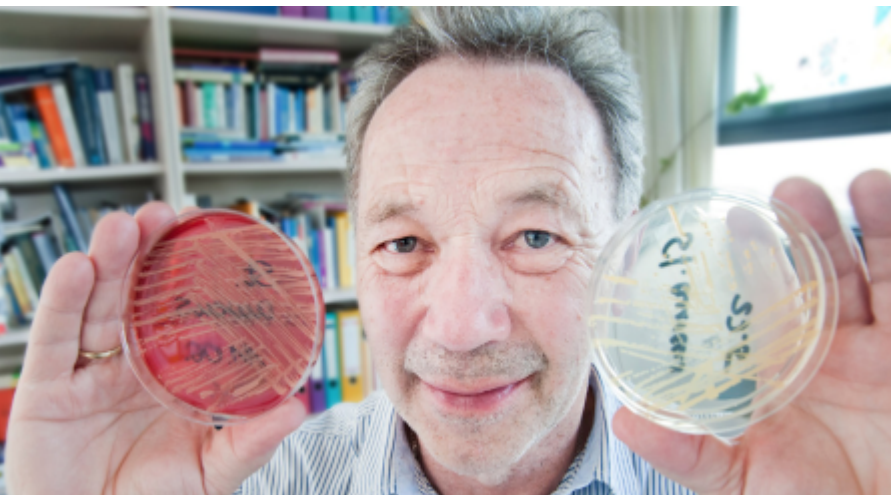


Dr. Matthias Gabriel, a chemist, works for the Department of Cardiothoracic and Vascular Surgery at the Johannes Gutenberg-University School of Medicine in Mainz, Germany. His main goal is to develop surfaces for materials that come into close contact with the human body. Examples are implants that are meant to become integrated into the living body or blood-contacting vascular devices. Materials used in these applications frequently suffer from poor biocompatibility which means that rejection may happen or – in the case of vascular grafts – blood clotting and clogging occurs. The material surfaces that come into close proximity with the surrounding cells and tissue are mainly responsible for the biological response which can be manipulated by an adequate modification.

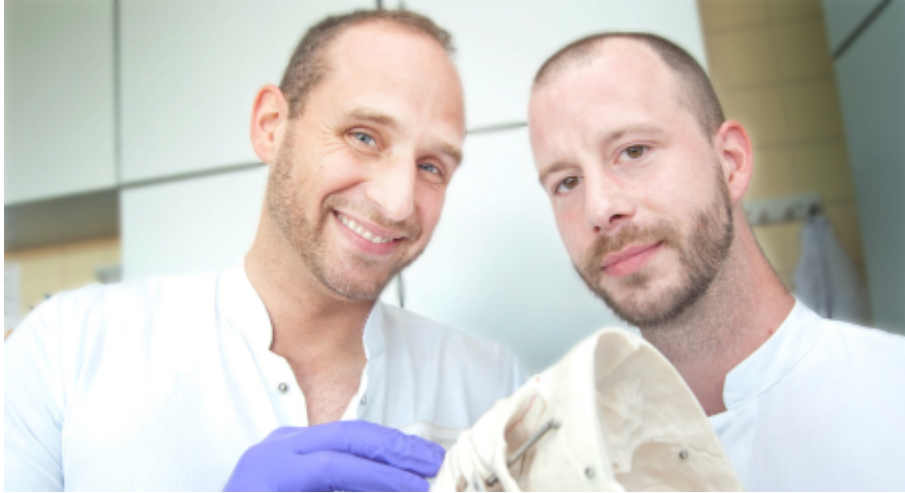
This so-called biomimetic approach - simulating natural interactions on synthetic materials - combines chemistry and biology in order to improve the implants performance.



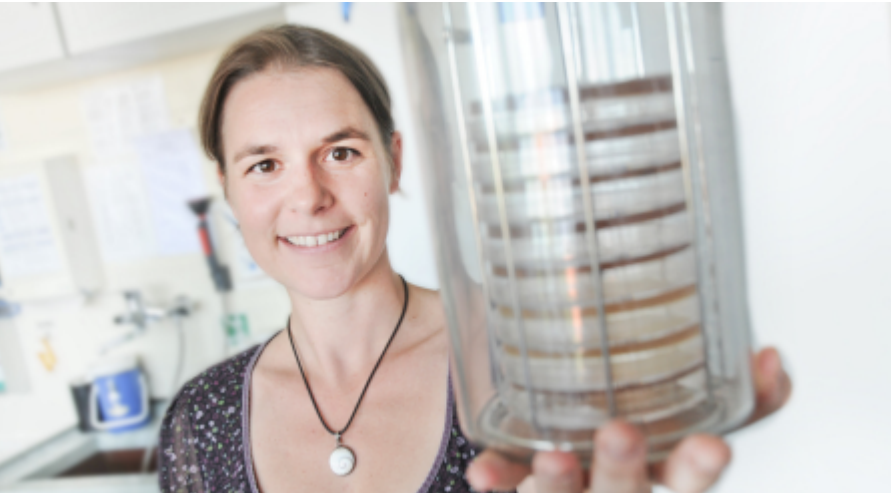
PD Dr. Alexander Hofmann, Consultant Surgeon and Head of Research in the Center for Orthopaedic and Trauma Surgery focuses in his research on the use of biomaterials in fracture healing. Modifications of implant materials, understanding of cell-cell and cell-biomaterial interactions including induction of angiogenesis, their vascularization potential and their influence on fracture healing are main topics of his engagement. To reach these goals he co-operates with material scientists and industrial companies. Currently, he is conducting a randomized multicenter clinical trial (16 trauma centers in Germany) investigating the use of a novel bone substitute for treatment of tibia plateau fractures as principle investigator.



Prof. Dr. Dr. Bernd Jansen studied chemistry and medicine at the University of Cologne and currently is the head of the Department of Hygiene and Environmental Medicine and of the Department of Hospital Hygiene at the University Medical Center of Mainz. He is specialist for Hygiene and Environmental medicine and also specialist in Microbiology, Virology and Infection Epidemiology. His main fields of research are (antibiotic) drug resistance, occurrence and transmission of antibiotic resistant bacteria in the environment and prevention of nosocomial infections in hospital, in particular prevention and control of catheter-related infections, being coeditor of "Catheter related infections", Marcel Dekker Publ., 1st and 2nd ed. Currently he is project leader in the EU project "Bacteriosafe" which has started in June 2010 for a period of 4 years dealing with the development of intelligent wound dressings based on nanoparticle technology.



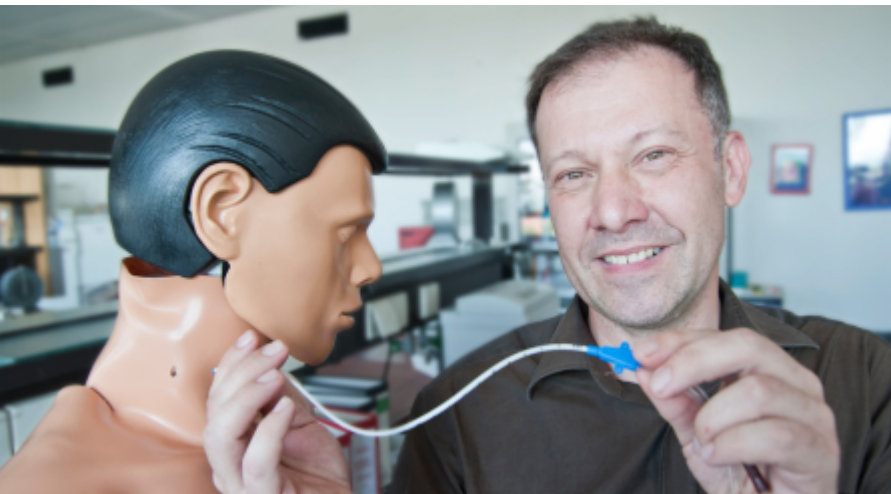
Dr. Dr. Peer W. Kämmerer, (University Mainz, Germany, Harvard Medical School, USA and M.R. Ambedkar Dental College, India) is specialist of Oral-, Maxillofacial and Plastic Surgery. Together with his international group (Germany, USA, India, Moldova) consisting of various clinicians and natural scientists and coordinated by **Dr. Martin Heller** and himself, intensive in vitro and in vivo research with focus on reconstruction of soft and hard tissues of the facial skeleton is conducted. This includes interactions of various biomaterials with platelets and growth factors, cellular reactions (stem cells, osteoblasts, endothelial cells, fibroblasts) and finally the application of chemical, biological, physical and biomimetical stimuli to the living organism. "The aim of our group is guidance and enhancement of the physiological healing reaction in order to help patients, which literally "lost their face".



Dr. Dr. Julia Karbach, (University Medical Center Mainz, Germany) focuses on the research of peri-implantitis. Oral pathogens can cause an infection of the soft and hard tissues around oral implants. This may lead to a loss of bone, which causes a loosening or even a loss of the implant. The research-group studies the composition of the microflora and in which degree of resistance the microflora reacts to antibiotics around dental implants in healthy and infected patients. Furthermore, the impact of the bacteria and of specific human cells, the fibroblasts and osteoblasts, on the material of the implants in vitro is of special interest. Thereby the research is based on the therapy of peri-implantitis in clinical studies. In cooperation with international groups and material scientists new antibacterial materials are tested to improve the therapy of these kind of infections.



As a consultant at the clinic of oral, maxillofacial and plastic surgery, **PD Dr. Dr. Felix Koch** focuses his clinical work on facial plastic and reconstructive surgery, supported by a CAD/CAM company, he founded together with the University medical center of Mainz. The emerging field of regenerative medicine and tissue engineering are therefore of great interest. He works on the potential of growth factors to rebuild bone by clinical trials, animal studies as well as in vitro cell culture experiments. Furthermore, he focuses on the differentiation of osteoblasts and multipotent stem cells, and their interaction with bone substitute materials. At the Plastic & Reconstructive Surgery Department at the Yale School of Medicine he studies the influence of specific recombinant proteins on premature cranial synostosis in mutant mice and the calvarial bone reconstruction by distraction osteogenesis in a rabbit model using a new distraction device and adding adipose derived stromal cells, supported by the DFG.



Dr. Wolfgang Kohnen is chemist and is the Research Team Leader of two research teams at the Department of Hygiene and Environmental Medicine at the University Medical Centre of Mainz . His main research topics are in the field of hospital hygiene and infection control concerning prevention of catheter or implant-associated infections by modification of the material surfaces. He was project leader in several research projects funded by the government (BMBF), e.g. dealing with the occurrence and spread of antibiotic resistant bacteria in hospitals and in the aquatic environment. Currently he is editor of the journal "Zentralsterilisation".



Dr. Sebastian Kuhn, Orthopaedics and Trauma Surgeon, works at the Center for Orthopaedic and Trauma Surgery. His research focuses on cell anti-adhesive surface modification on clinically used titanium implants. Model surfaces are developed with the ability to reduce fibroblast and osteoblast adhesion and proliferation. Project partners are the Max Planck Institute for Polymer Research and the Institute for Microtechnology Mainz.



PD Dr. Mailänder is board certified in transfusion medicine and works in the III. Medical Clinic (Hematology, Oncology and Pulmonology) in the Stem Cell Lab as qualified person. The scientific work is focused on combining nanocarriers with human stem und immune cells. This offers a plethora of possibilities for enhancing the effectiveness of cellular therapeutics like tumor specific T cells or cells pre-seeded on a biomaterial to provide a graft. Especially the routes of entry and the trafficking of nanocarriers inside of cells are of crucial importance for such applications and a focus of the group. Herefore nanosized capsules between 10 and 300 nm are used as carriers for drugs and diagnostic substances. They are designed in close cooperation with the Max-Planck-Institute for Polymer Research, Mainz. This includes the design and synthesis of functionalized biodegradable nanoparticles/nanocapsules for site specific drug delivery, imaging in vivo, and controlled release of a drug within the targeted cells.



Prof. Dr. Werner E.G. Müller is leader of the ERC Advanced Grant Research Group “Biosilica” at the University Medical Center of the Johannes Gutenberg University of Mainz, Vice-President of IMBA [International Marine Biotechnology Association] and coordinator of several ongoing EU FP7 projects, including the large-scale integrating project “BlueGenics” on exploiting marine genomics for nano-biomedical applications (such as the therapy of osteoporosis) and the ERC-Proof-of-Concept project Si-Bone-PoC on the development of biosilica-based approaches for treatment of bone diseases. Werner E.G. Müller is an outstanding expert in the elucidation and characterization of genes and proteins involved in biomineralization, in particular in the field of marine invertebrates where his team is world-wide leading, and their application in biomedicine and biotechnology, but also in the development of novel chemotherapeutics. Several drugs discovered or characterized by him are in clinical use. His results have been published in more than 1000 publications (Hirsch h-index: 62) and 20 granted patents. In addition, he is Distinguished Professor of the Chinese Academy of Sciences, Honorary Professor of the Chinese Academy of Geosciences and Guest professor at Tsinghua University Beijing. He has received numerous awards, including the Human Frontier Science Program, and more recently, the Friendship Award by Premier Wen Jiabao, the P.R. China's highest award for foreign experts. His Center of Excellence “BIOTECmarin – Biomaterials from the Sea” has been selected as a “Landmark” in the national campaign “Germany - Land of Ideas”.



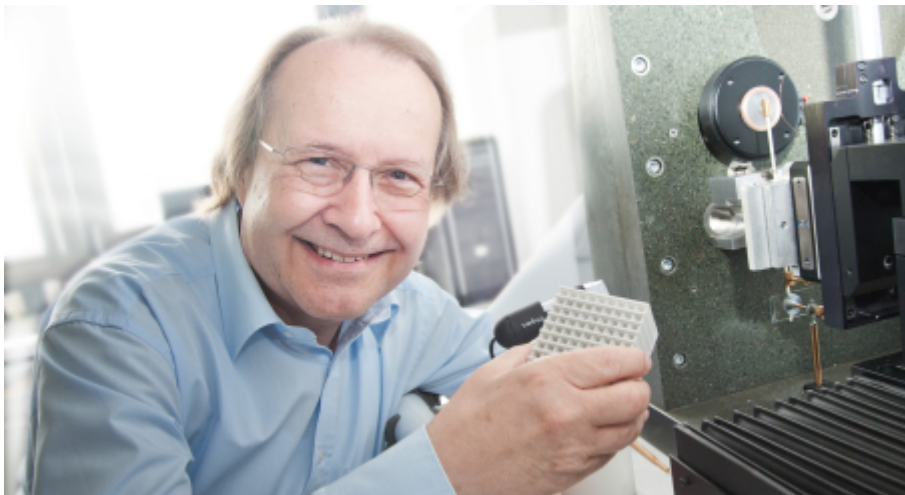
Dr. Thomas Nusselt, Consultant Surgeon, works in the Center for Orthopaedic and Trauma Surgery. His research focuses on the use of biomaterials in fracture healing; in particular, implant materials used as scaffolds for bone healing in fracture defects and bone substitutes. Currently, he is part of a randomized multicenter clinical trial (16 trauma centers in Germany) investigating the use of a novel bone substitute for treatment of tibia plateau fractures as sub-investigator.



Dr. Ulrike Ritz works as a biologist and is project leader in the Center for Orthopaedic and Trauma Surgery. Her main topic is the use biomaterials in fracture healing. In her research projects she focuses on the use of biological polymers (collagen- and hydrogels) and analyses three dimensional cell culture models in these polymers. She modifies her gels with various growth factors and / or cytokines and investigates their influence on her cell culture models. She co-operates with material scientists and supervises Ph.D. students performing their practical thesis.



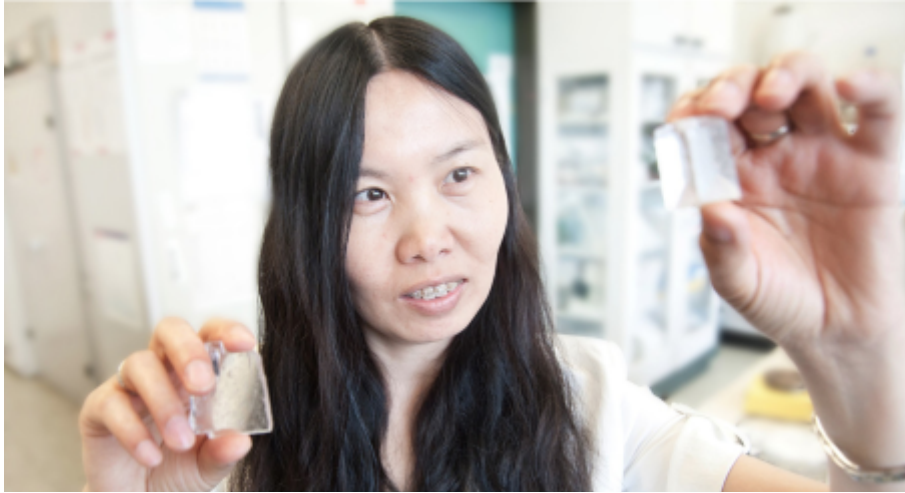
Prof. Dr. Laura Schreiber, develops new biomedical imaging methods to measure und visualize physiologic parameters non-invasively. She is enthusiastic about highly interdisciplinary projects which often involve disciplines like physics, medicine, biomedical engineering, mathematics, chemistry, or others. Recently, she used hyperpolarized Helium-3 gas with magnetic resonance imaging (MRI) to visualize lung diseases like asthma or COPD. One of her other key interests is research on tissue microcirculation where she and her group develop new techniques for assessment of stroke and myocardial infarction. Massively parallel MRI and computational methods help her generate best images from the human body, and to understand fluid transport process.



Prof. Dr. Dr. Heinz C. Schröder is a chemist and physician and professor at the University Medical Center of the Johannes Gutenberg University Mainz. He has been involved, together with Werner E. G. Müller, in the coordination of more than 20 European projects in FP4, FP5, FP6 and FP7, including a Marie Curie Initial Training Network on biomineralization ("BIOMINTEC"). His current research interests are focused on the mechanisms of biomineral formation, in particular biosilicification and its application in nanomedicine and nanobiotechnology. In addition, he has discovered several new proteins and enzymes involved in essential steps of gene expression. Heinz C. Schröder has more than 10 patents granted in the field of analytical biochemistry, biotechnology, bone repair/osteoporosis and bioactive compounds and is author or co-author of more than 400 scientific articles (Hirsch h-index: 47). He has received several awards in recognition of his work in particular in the fields of molecular gerontology and biomedicine.



Dr. Ronald Unger is senior scientist in the REPAIR Lab (Laboratory for Regenerative Pathology and Interface Research) in the Institute of Pathology. The major focus of research is the evaluation of human cell-compatibility and functioning of cells in their interaction with novel materials destined for use in or on humans. Using advanced cell and molecular biological methods, the goal is to determine how biomaterials affect cell structure and function by developing in vitro model systems mimicking tissues and organs in the in vivo situation. Single and multicell coculture systems have been developed using freshly isolated primary human cells as well as human cell lines to study the cell responses of the different cell types in their interaction with different 2- and 3-D natural and synthetic biomaterials. A major focus has been on endothelial cell interactions as these cells are involved in the vascularization of biomaterial implants, in angiogenesis in the healing response and as one of the first cells encountered after injection of a material or drug. Models representing angiogenesis, bone, lung, blood-brain barrier, skin/mucous membrane and cartilage have been developed to evaluate scaffold biomaterials for tissue regeneration or micro- and nanoparticles for drug delivery as well as novel materials for, for example, wound treatment or brain tissue regeneration. The ultimate goal of these in vitro studies is to determine how structure and chemical make-up of materials affect and interact with human cells to understand biomaterial-related pathology and compatibility in order to reduce animal studies and to identify factors to improve biomaterials and implants for regenerative medical and drug delivery applications.



Prof. Dr. Xiaohong Wang is scientific coordinator of the German-Chinese Joint Center on “Bio-inspired Materials” at the University Medical Center of the Johannes Gutenberg University Mainz and has been involved, as a coordinator or participant, in several European projects, including the EU FP7 projects “Bio-Scaffolds” in the EU-China programme on “Biomaterials: Imaging and rapid precise prototyping technology for custom made scaffolds”, “CoreShell” and “BlueGenics”, and the European-Chinese Research Staff Exchange Cluster MarBioTec*EU-CN*. Xiaohong Wang is an expert in material sciences, with a special focus on biomaterials; she has more than 140 publications (Hirsch h-index: 21). She was the first who discovered, together with Werner E.G. Müller and her colleagues at the Institute for Physiological Chemistry, the biogenic origin of the deep-sea polymetallic nodules and seamount crusts, as well as the unique mechanical and biomedical properties of the biosilica material from siliceous sponge spicules, making this material to a new and exciting source of inspiration in bone tissue engineering.



Dr. Dr. Dr. Thomas Ziebart, consultant surgeon and biologist in the Department of maxillofacial surgery and plastic surgery focuses in his research of hart and soft tissue regeneration on the use of different dental membrane and bone substitute in vitro and in vivo as well as in clinical studies. One focus of Dr. Ziebart's group is the influence and importance of angiogenesis and neovascularization triggered by endothelial progenitor cells (EPC) and matured endothelial cells for increased osseointegration and soft tissue healing. "Trendsetting research can only be done in the context of strong cooperation: Therefore we work together with other national and international groups and industrial companies to reach our goals."

Scientific Board of Directors

Prof. Dr. Ulrich Förstermann (Chief Scientific Officer of the Johannes Gutenberg University Medical Center and Dean of the Faculty of Medicine, Johannes Gutenberg University, Mainz)

Prof. Dr. Holger Frey (Institute of Organic Chemistry, Johannes Gutenberg University, Mainz)

Prof. Dr. Dr. Charles James Kirkpatrick (Institute of Pathology, Johannes Gutenberg University, Mainz)

Prof. Dr. Katharina Landfester (Max Planck Institute of Polymer Research, Johannes Gutenberg University, Mainz)

Prof. Dr. Dr. h.c. Pol Maria Rommens (Department of Trauma and Orthopaedic Surgery, University Medical Center Mainz)

Prof. Dr. Wolfgang Tremel (Department of Chemistry, Johannes Gutenberg University, Mainz)

Prof. Dr. Dr. Wilfried Wagner (Department of Oral and Maxillofacial Surgery, University Medical Center Mainz)

Prof. Dr. Dr. Bilal Al-Nawas (Spokesman of BiomaTiCS)

National Cooperation Partners

Dr. Lars Choritz (Clinic for Ophthalmology, Otto von Guericke University, Magdeburg)

Dr. Renate Förch (IMM Institute for Microtechnology, Johannes Gutenberg University, Mainz)

Dr. Dr. Shahram Ghanaati (Clinic for Maxillofacial and Plastic Surgery, Johann Wolfgang Goethe University, Frankfurt/Main)

Dr. Sebastián Hagmann (Department for Orthopaedics, Trauma Surgery and Paraplegiology, Heidelberg University Hospital)

Prof. Dr. Anita Ignatius (Institute of Orthopaedic Research and Biomechanics, University of Ulm)

Prof. Dr. Ulrich Jonas (Macromolecular Chemistry, University of Siegen)

Dr. Kaloian Koynow (Max Planck Institute for Polymer Research, Johannes Gutenberg University, Mainz)

Prof. Dr. Katharina Landfester (Max Planck Institute for Polymer Research, Johannes Gutenberg University, Mainz)

Prof. Dr. Peter Langguth (SAMT, Johannes Gutenberg University, Mainz)

Prof. Dr. G. Ulrich Nienhaus (Institute for Applied Physics, Karlsruhe Institute of Technology)

Dr. Ralf Sanzenbacher (Paul - Ehrlich - Institut, Langen)

Prof. Dr. Hubert Schrezenmeier (Institute for Clinical Transfusion Medicine and Immunogenetics, Ulm)

Prof. Dr. Wolfgang Tremel (Department of Chemistry, Johannes Gutenberg University, Mainz)

Prof. Dr. Michael Veith (Department of Molecular Biology, Westphalian University, Recklinghausen)

Dr. Rolf Zehbe (Institute for Material Sciences and Technologies, Department of Materials Engineering, Technical University, Berlin)

Prof. Dr. Rudolf Zentel (SAMT, Johannes Gutenberg University, Mainz)

International Cooperation Partners

Abdulmonem Alshihri DDS (Department of Restorative and Biomaterial Sciences, Harvard School of Dental Medicine, Boston, MA, USA)

Vinay V. Kumar (Oral- and Maxillofacial Surgeon, M.R. Ambedkar Dental College Bangalore, Indien)

Yong-Dae Kwon DMD, MSD, PhD (Associate Professor, Dept. of Oral and Maxillofacial Surgery, Kyung Hee University School of Dentistry, Seoul, Korea)

Dr. Victor Palarie (State University of Medicine and Pharmaceuticals „Nicolae Testemițanu" Laboratory of Tissue Engineering and Cellular Culture, Chisinau, Moldova)

Myron Spector PhD (Professor of Orthopedic Surgery, Harvard Medical School, Boston, MA, USA)

Derek M. Steinbacher DMD, MD (Assistant Professor of Surgery and Pediatrics, Yale School of Medicine, USA)

Imprint

Published by

BiomaTiCS
University Medical Center Mainz
Department of Oral and Maxillofacial Surgery
Augustusplatz 2
55131 Mainz
phone: +49 6131 173083
<http://www.unimedizin-mainz.de/biomatics/uebersicht.html>

Editors

Prof. Dr. Dr. Bilal Al-Nawas, Dr. Jutta Goldschmitt

Contact

e-mail: sprecher@biomatics-mainz.de

Layout

Matthias Gielisch

Photos

Markus Schmidt, photographer
University Medical Center Mainz

Edition

First edition, 2013

All rights reserved. No part of this publication may be reproduced in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior permission of the publisher.

Prof. Dr. Dr. Bilal Al-Nawas

BiomaTiCS, University Medical Center Mainz

Department of Oral and Maxillofacial Surgery

Augustusplatz 2, 55131 Mainz

phone: +49 6131 173083, e-mail: sprecher@biomatics-mainz.de

homepage: <http://www.unimedizin-mainz.de/biomatics/uebersicht.html>

