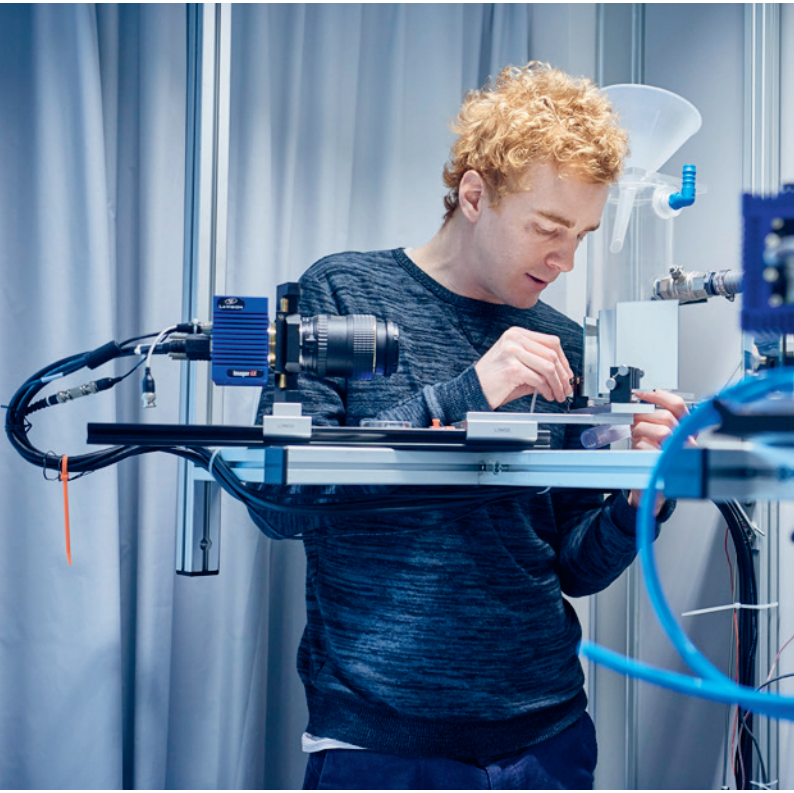
UNIVERSITÄT
BERN

ARTORG CENTER
BIOMEDICAL ENGINEERING RESEARCH

# Research Portfolio
# ARTORG Center



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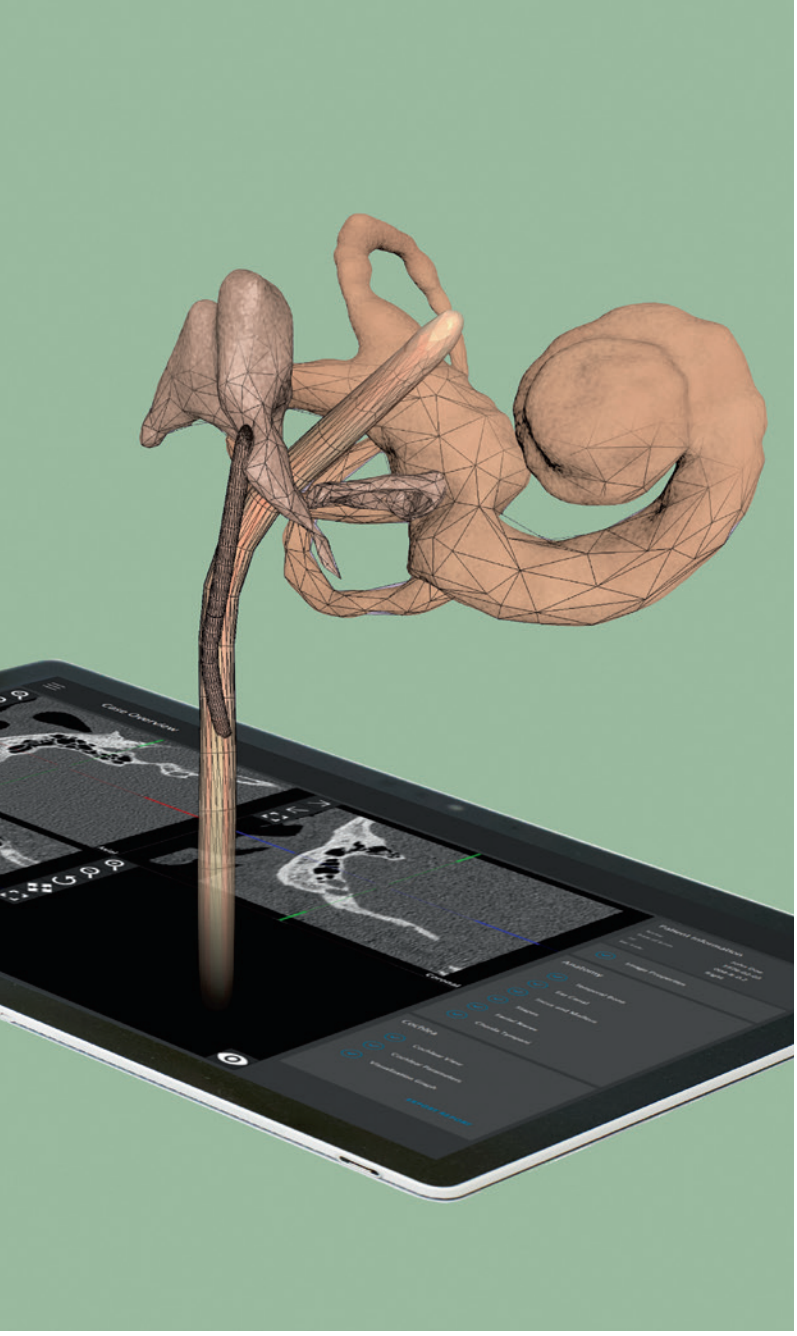


**Image-Guided Therapy**
Photorealistic rendering of relevant anatomical structures for ear surgery planning based on computed tomography images.

*Graphics: Catherine Tsai*

# Innovation that improves clinical reality

The ARTORG Center for Biomedical Engineering Research is the interdisciplinary medical technology research hub of the University of Bern and the Inselspital, Bern University Hospital. As an engineering department within a medical faculty our projects are, by design, close collaborations of engineers, computer-, material-, life-scientists, biologists and clinicians. Our mission is to envision future challenges and embody viable solutions in healthcare technology with imagination, agility and purpose.

The research questions at the ARTORG Center arise from the limitations that clinicians face as part of everyday patient care. Eleven independent, interdisciplinary groups make up our matrix research structure. Our translational strategy seeks to convert ARTORG research into new treatments through a deep commitment to specific clinical focus areas. Technical and clinical research leads jointly define the inovation requirements for our flagship projects in each focus area. The ARTORG spin-off ventures with products in the clinic and on the market are evidence of the successful translation of our research.

We are proud to educate a new generation of Biomedical Engineering researchers and future industry leaders, with a unique program of combined technical and clinical postgraduate training: the Master's in Biomedical Engineering conferred by the Medical Faculty of the University of Bern and the Berner Fachhochschule.

The ARTORG is fortunate to be part of a varied and extensive network of National and International academia, industry and policy makers. Through these close collaborations we have achieved a leadership role in Biomedical Engineering research in the Canton of Bern and beyond. Our patients, partners and team members continue to inspire us in our work and vision for better treatments now and in the future.

**Raphael Sznitman**
Director

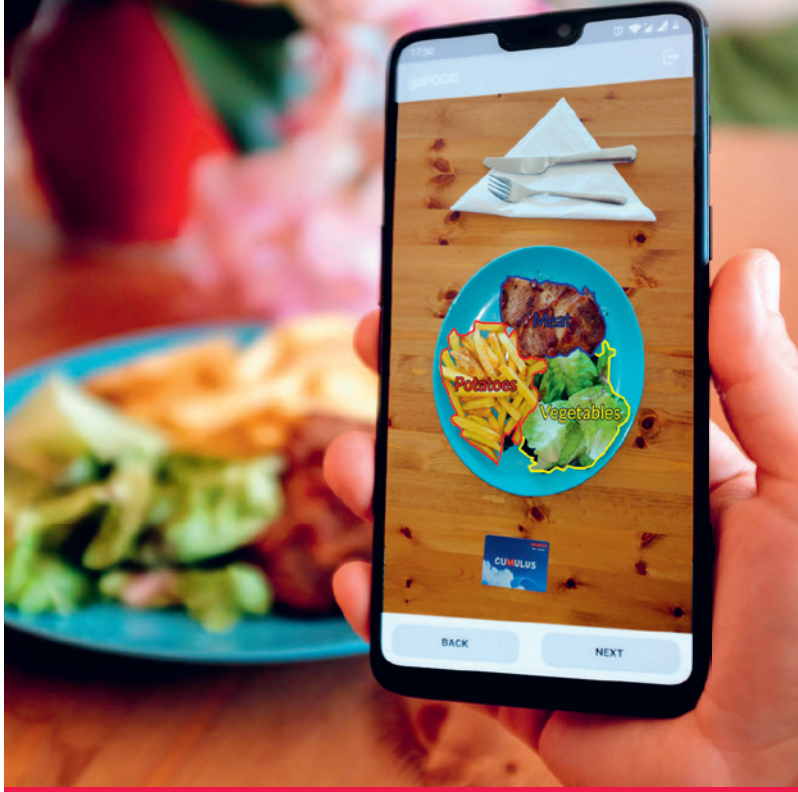
# Artificial Intelligence in Health and Nutrition

## Research profile

The AI in Health and Nutrition Laboratory focuses primarily on the interface between machine learning, artificial intelligence and their applications to improving health.
The laboratory creates innovation to translate "data into knowledge" and "research into clinical practice."

**Our research activities:**

- AI-based innovative systems for dietary monitoring and assessment
- Reinforcement learning for optimization of insulin treatment
- AI-based computer-aided diagnosis for lung diseases




AI-based algorithms automatically detect food types, estimate portion sizes and calculate the calories, carbohydrates, protein and fat from smartphone photo or video.

*Photo: Thomai Stathopoulou and Stergios Christodoulidi*


**Group head**
**Stavroula Mougiakakou**

**Clinical partners**
**Johannes Heverhagen & Andreas Christe** / University Clinic of Diagnostic, Interventional and Pediatric Radiology, Inselspital

**Zeno Stanga** / Department for Diabetology, Endocrinology, and Nutritional Medicine and Metabolism, Inselspital

**Peter Diem** / Prof. em. Department of Endocrinologie & Diabetology, Inselspital

**Thomas Geiser** / Department of Pneumology, Inselspital

**Aristomenis Exadaktylos** / Department of Emergency Medicine, Inselspital

**Elias Spanakis** / School of Medicine, University of Maryland, USA

# Cardiovascular Engineering

## Research profile

The Cardiovascular Engineering (CVE) group studies cardiovascular flows and diseases, such as valvular heart disease and myocardial infarction. Our research aims to improve the long-term durability and biocompatibility of therapeutic devices and implants and to develop novel diagnostic tools. The translational research projects address immediate clinical needs that were identified together with our clinical partners who are closely integrated in the project teams from start to finish.

**Our research activities:**
CVE operates an experimental flow lab with modern measurement technology and a computational lab to model flows in the heart and blood vessels.

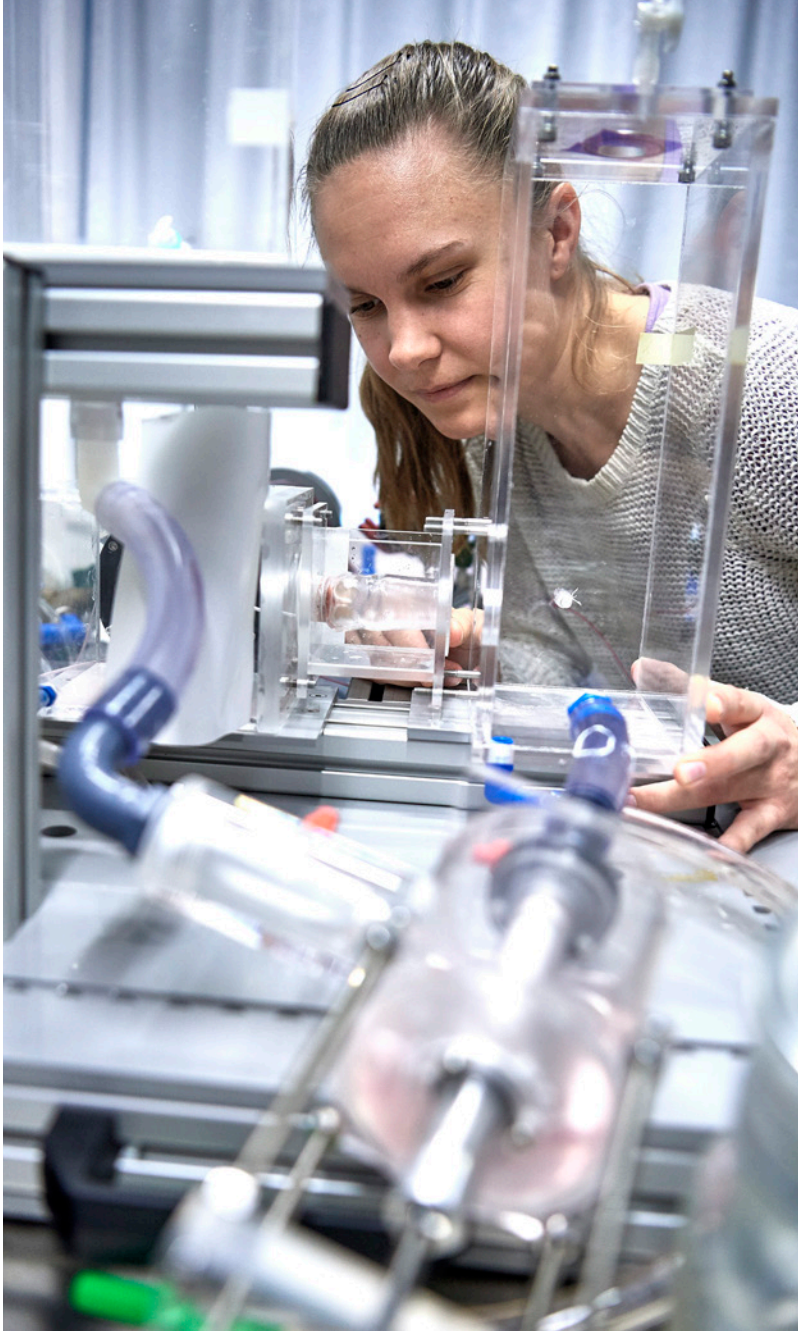
- Our experimental facilities include high-speed cameras and laser-based methods for three-dimensional flow quantification.
- We develop and use custom-tailored computer models of biomedical flow systems with fluid-structure interaction.
- Efficient use of high-performance computing technology enables the integration of our computer models into clinical practice.

**Group head**
**Dominik Obrist**

**Clinical partners**
**Iris Baumgartner** / Department of Angiology, Inselspital

**Thierry Carrel** / Department of Cardiovascular Surgery, Inselspital

**Stephan Windecker** / Department of Cardiology, Inselspital



Experimental study of an artificial heart valve in a pulsatile flow loop modelling the left heart.

*Photo: Adrian Moser*

# Artificial Intelligence in Medical Imaging

## Research profile

The Artificial Intelligence in Medical Imaging (AIMI) Laboratory works on novel methods that apply Artificial Intelligence (AI) methods to develop clinical tools that use medical images for diagnostics, interventional radiology and surgical robotics.

The rise in patient numbers without matched clinical resources and the impact of time-consuming manual diagnostic modalities are foreshadowing serious bottlenecks in treatment capacities for healthcare delivery systems. However, the recent availability of high-accuracy and high-throughput clinical grade AI tools could be part of a sustainable solution to address this crisis in clinical care. In close collaboration with clinicians, biologists and other health practitioners, we investigate data-driven, virtual versions of the traditional hardware instruments that have constituted the "doctor's toolkit" of clinicians for centuries.

**Our research activities:**

- AI tools for ophthalmology
- Image-guided methods for surgical robotics
- Computer vision for microscopy and radiology
- Machine Learning for Astronomy

**Group head**
**Raphael Sznitman**

**Clinical partners**
**Sebastian Wolf** / Department of Ophthalmology, Inselspital

**René Höhn** / Department of Ophthalmology, Inselspital

**Marion Munk** / Department of Ophthalmology, Inselspital

**Kevin Heng** / Center for Space and Habitability, University of Bern

# Computational Bioengineering

## Research profile

Our group focuses on the development of in-silico computational models in different medical fields such as oncology, ophthalmology, or orthopedics. Advanced clinical imaging is combined with innovative experimental and numerical approaches to obtain an accurate biomechanical description of patient tissues. Computational models enable a deeper understanding of the biomechanical parameters responsible for certain pathologies, they provide new insights on surgical treatments and improve surgical planning.

**Our research activities:**

- Mathematical modeling of the biomechanical forces causing brain tumor mass-effect
- Planning of refractive interventions for vision correction such as myopia or astigmatism
- Finite element analysis of peripheral arterial disease
- Intraoperative quantification of spinal biomechanics

**Group head**
**Philippe Büchler**

**Clinical partners**
**Carol Hasler** / Orthopedic Department, University Children's Hospital Basel

**Alain Farron** / Service of Orthopedics and Traumatology, Lausanne University Hospital

**David Piñero Llorens** / Department of Optics, Pharmacology, and Anatomy, University of Alicante

**Rolf Engelberger** / Division of Angiology, Fribourg cantonal hospital

**Lorenz Räber** / Department of Cardiology, Inselspital

The ARTORG Center combines the knowhow of engineers, computer-, material-, life-scientists, and clinicians to envision and realize technological solutions to real-life unmet clinical needs, fostering translation through academic, health care and industry partnerships.

*Photo: Adrian Moser*

# Gerontechnology and Rehabilitation

## Research profile

Gerontechnology and Rehabilitation technology aim to restore cognitive, sensory and motor functions lost as the result of illness or accident. The relevance of these fields increases with the aging of our society. In this context, the group develops and evaluates neurorehabilitation technology for patients with brain injury and neurodegenerative diseases to enhance autonomy and promote independent living. Current projects aim to promote independent living with assistive technology, ICT-based tools for training and prevention of cognitive decline and virtual reality assisted rehabilitation.

**Our research activities:**

- Tele-rehabilitation technologies (speech, visual perception, and cognitive assessment and training)
- Computer-based cognitive assessment and training (Virtual reality, Serious and Casual Games)
- Ambient sensor technologies for quantifying functional outcomes

**Technical group head**
**Tobias Nef**
**Clinical group heads**
**René Müri, Urs Mosimann**

**Clinical partners**
**Stephan Jakob and Joerg Schefold** / Department of Intensive Care Medicine, Inselspital

**Paul Krack** / Department of Neurology, Inselspital

**Stefan Klöppel** / University Hospital of Psychiatry, University of Bern

**Thomas Nyffeler and Stephan Bohlhalter** / Department of Internal Medicine, Luzerner Kantonsspital

**Martin Schimmel** / Division of Gerodontology, School of Dental Medicine, University of Bern

# Hearing Research Laboratory

## Research profile

The Hearing Research Laboratory (HRL) develops technology for the diagnosis and treatment of inner ear diseases including hearing loss, tinnitus and vertigo. Together with the Department of Ear, Nose and Throat Diseases, Head and Neck Surgery (ENT) at the Inselspital Bern, we form a multidisciplinary group with experts from the fields of audiology, otolaryngology, neurology, physics, and engineering.

**Our research activities:**

- Modelling and simulation of the inner ear anatomy and physiology
- Robotic sound field audiometry
- Tinnitus and balance diagnostics
- Auditory implant surgery and technology

**Group head**
**Wilhelm Wimmer**

**Clinical partners**
**Marco Caversaccio / Martin Kompis / Georgios Mantokoudis**, Department of ENT, Head and Neck Surgery, Inselspital

**Deborah Hall** / NIHR Nottingham Biomedical Research Centre, University of Nottingham, UK

**Tobias Kleinjung** / University Hospital of Zurich

**Nicolas Guevara** / Centre Hospitalier Universitaire de Nice, FR

# Image-Guided Therapy

## Research profile

Continuous advancements in simulation and modelling, imaging and sensing, visualization and robotics are being transferred into applications for use in medical technologies. The Image-Guided Therapy group investigates approaches and technologies that can take over tasks in medical procedures better performed by "machines" compared to human operators. We move translational projects into the clinic in close collaboration with clinical and academic co-investigators at the Inselspital and in cooperation with other national and international partners.

**Our research activities:**

- Minimally invasive liver cancer treatment (planning and navigation for ablations)
- Roboter-assisted cochlear implantation
- Robotic spine and brain surgery

**Group head**
**Stefan Weber**

**Clinical partners**
**Daniel Aebersold** / Department Radiation Oncology, Inselspital

**Iris Baumgartner** / Department of Angiology, Inselspital

**Daniel Candinas** / Department of Visceral Surgery and Medicine, Inselspital

**Marco Caversaccio** / Department of ENT, Head and Neck Surgery, Inselspital

**Jan Gralla** / University Institute of Diagnostic and Interventional Neuroradiology, Inselspital

**Martin Maurer** / Department of Diagnostic, Interventional and Pediatric Radiology, Inselspital

**Andreas Raabe** / Department of Neurosurgery, Inselspital

# Mechanical Design and Production

## Group profile

The primary function of the Mechanical Design and Production (MDP) group is the co-development and manufacturing of mechanical and electro-mechanical components related to research projects of the ARTORG Center. The MDP group supports all levels of the design and manufacturing process from concept to production. This includes Computer Assisted Design (CAD) modelling, prototyping and production with technical drawings, standard tooling, Computer Assisted Manufacturing (CAM), a CNC-milling-machine, and a CNC-lathe. We also support external industrial and academic research collaborators with their mechanical design and production needs.

**Our research activities:**

- Training and education: Apprenticeship Poly-Mechanic
- Research Equipment Design & Manufacturing

**Group head**
**Urs Rohrer**

# Musculoskeletal Biomechanics

## Research profile

Motivated by prevention, diagnosis and treatment of degenerative diseases the research of the Musculoskeletal Biomechanics group focuses on multi-scale structure-function relationships of musculoskeletal tissues from the extracellular matrix to the organ level. A combined theoretical, experimental, and numerical approach is applied to model, validate and simulate the mechanical behavior of musculoskeletal tissue in the course of growth, aging, disease and treatment. The group provides biomechanical testing services and cooperates with local, national as well as international partners from academia, hospitals and industry to help reduce the burden of musculoskeletal diseases and failure of the tissue-implant interface.

**Our research activities:**

- Multiscale structure-function relationships in musculoskeletal tissues
- Computer simulation of musculoskeletal tissues and tissue-implant interfaces
- Bone fracture risk prediction for diagnosis and prevention

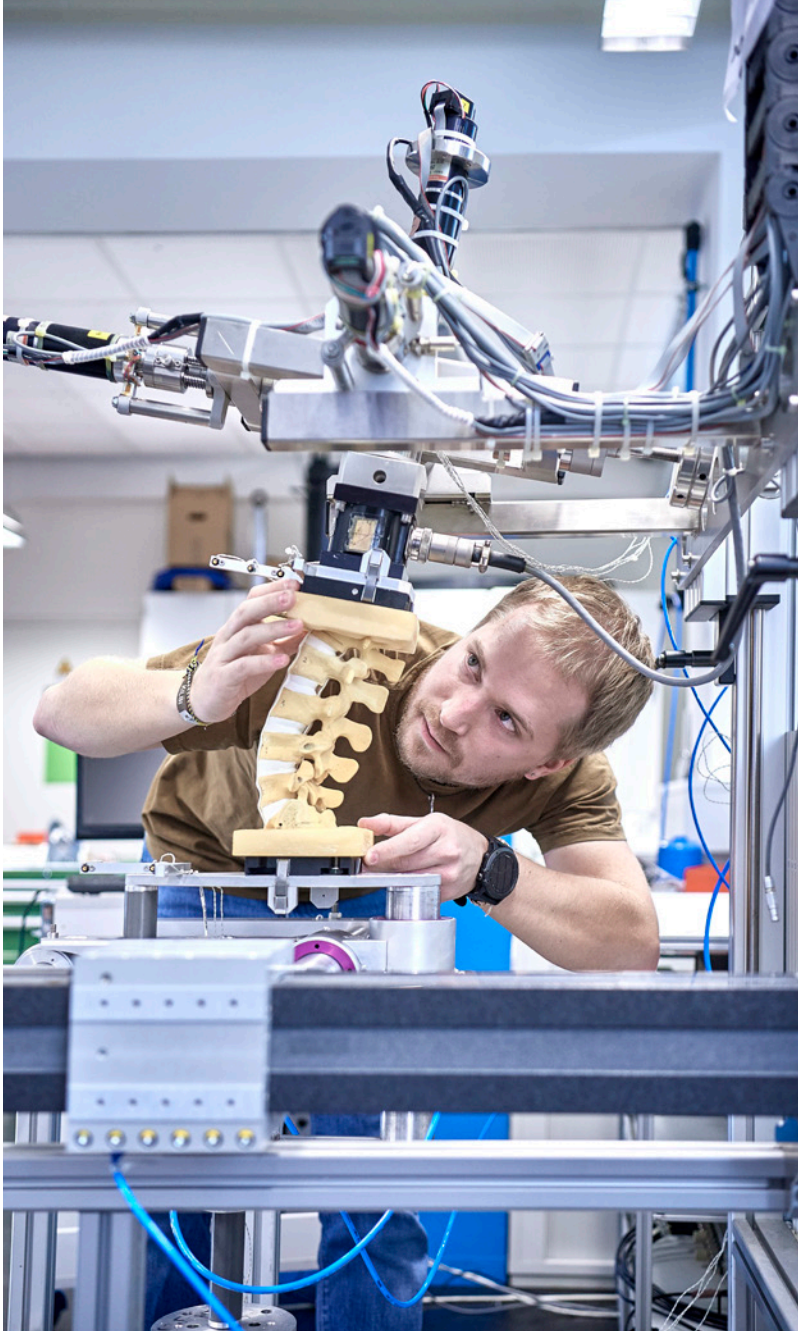
**Group head**
**Philippe Zysset**

**Clinical partners**
**Serge Ferrari** / Division of bone diseases, Geneva University Hospitals (HUG)

**Johannes Heverhagen** / Department of Diagnostic, Interventional and Pediatric Radiology, Inselspital

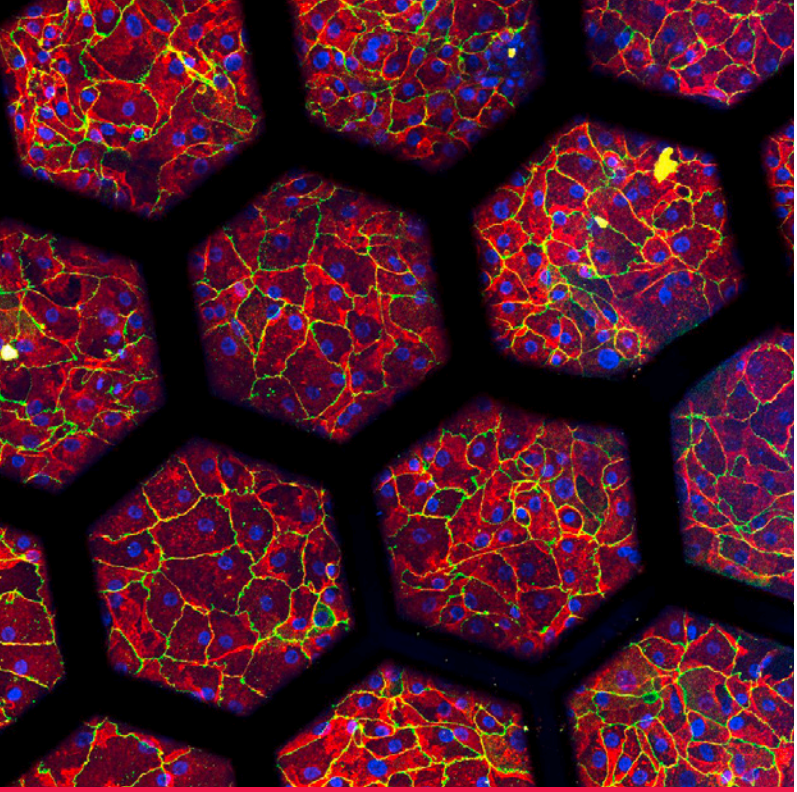
**Kurt Lippuner** / University Polyclinic of Osteoporosis, Inselspital

**Klaus Siebenrock** / Department of Orthopaedic Surgery and traumatology, Inselspital



Evaluation of the intervertebral disc function: calibration of a spine testing system.

*Photo: Adrian Moser*



Immunostaining of patient cell cultures on a second-generation lung-on-chip.

*Picture: Pauline Zamprogno*

# Organs-on-Chip Technologies

## Research profile

The Organs-on-Chip Technologies team develops advanced in-vitro models of the lung that accurately recreate the cellular microenvironment of the respiratory tract. Through interdisciplinary research at the interface of cell biology, lung physiology and mechanics, microtechnology, and microfluidics the group has built a unique breathing Lung-on-Chip system and a functional Lung Microvasculature-on-Chip.

Bioartificial lung-on-chip systems are powerful tools to gain an understanding of the cellular or molecular mechanisms of the healthy lung and how they can break down to drive the pathophysiology of lung diseases. They will also be at the center of delivering precision medicine, a new paradigm in which the treatment efficiency of drugs can be tested in advance on the patient's own cells to optimize therapies for each patient individually.

**Our research activities:**

- Healthy and diseased lung models based on microfluidics, tissue engineering and lung physiology
- Patients' specific organ-on-chip models for precision medicine
- Organs-on-chip for regenerative medicine applications

**Group head**
**Olivier Guenat**

**Clinical partners**
**Thomas Geiser** / Department of Pneumology, Inselspital

**Ralph A. Schmid** / Department of Thoracic Surgery, Inselspital

**Matthias Gugger** / Non-Invasive Ventilatory Care, Department of Pneumology, Inselspital

**Daniel Candinas** / **Deborah Stroka** / Department of Visceral Surgery and Medicine, Inselspital

# Motor Learning and Neurorehabilitation

## Research profile

The Motor Learning and Neurorehabilitation laboratory is an interdisciplinary group that gathers the knowledge and expertise of engineers, neuroscientists and psychologists. We strive for a better understanding of the mechanisms associated with the acquisition of novel motor skills to develop innovative technology that improves the rehabilitation of neurological patients. Our research focuses on the use of robotics and virtual reality to optimize motor learning and neurorehabilitation.

**Our research activities:**

- Employ robotic devices and machine learning algorithms to provide patient-centered neurorehabilitation
- Develop immersive virtual reality games to motivate patients during robotic training
- Understand the complex cognitive process of motor learning and neurorehabilitation through EEG

### Group head

**Laura Marchal-Crespo**

### Clinical partners

**René Müri** / University Neurorehabilitation, Department of Neurology, Inselspital

**Urs Mosimann** / Medical Director, Insel Gruppe

**Thomas König** / EEG Laboratory, Department of Psychiatric Neurophysiology, University Hospital of Psychiatry, University of Bern

**Fred Mast** / Cognitive Psychology, Perception and Research Methods, Institute of Psychology, University of Bern

**Kenneth Hunt** / Rehabilitation and Performance Technology, Bern University of Applied Sciences

# Urogenital Engineering

## Research profile

The Urogenital Engineering (UGE) group focusses on the understanding and treatment of diseases of the urinary tract (UT), many of which have a significant impact on quality of life. The elderly, who signify an increasing percentage of the total population, are most commonly affected by bladder dysfunction and the treatment and management of chronic UT diseases have considerable impact on healthcare costs.

Using innovative engineering approaches, the UGE group aims at developing new methods to diagnose and treat diseases of the urinary tract with special focus on the underactive-bladder, overactive-bladder, incontinence and kidney/ureteral stones. Our group has pioneered the use of new diagnostic approaches such as cardiac catheters for minimally-invasive electrophysiological investigations of the UT and analytical tools which allow the early detection of unwanted bladder contractions. Moreover, our research has resulted in a new testing platform for ureteral stents and the first non-invasive treatment device (URODEA) which can help empty the bladder in patients suffering from underactive-bladder.

### Group head

**Francesco Clavica**

### Clinical partners

**Fiona Burkhard** / Department of Urology, Inselspital

**Federico Soria** / Jesus Usón Minimally Invasive Surgery Centre, Cáceres, Spain

**Marcus Drake** / Bristol Urological Institute, Southmead Hospital, Bristol, UK

**CAScination AG**

Award-winning CAS-One IR targets liver cancer treatment through a pinhole. The technology is a result of research at the ARTORG and has benefitted over 3,000 patients worldwide.

*Photo: Adrian Moser*

**ARTORG Spin-Offs**

AlveoliX
In-vitro models inspired by nature

CASCINATION

Optimeyes

retinai

Surgeon's Lab

PeriVision
artificial intelligence in eye care

URODEA
Happy bladders

*Photo Cover: Cardiovascular Engineering Laser-based measurement of three-dimensional blood flow in a model of the aortic root.*
*Adrian Moser*

## Contact

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