### Audience
The Summer School is addressed to PhD students and postdoctoral researchers in biomedical engineering, biophysics, mechanical and civil engineering, applied mathematics and mechanics, materials science and physiology and more senior scientists and engineers (including some from relevant industries) whose interests are in the area of biomechanics and mechanobiology of soft tissues.

### Registration
The registration fee is 595 €. The fee covers the attendance at all lectures, and a book of lecture notes. In addition, lunch and light refreshments will be provided throughout the days; a guided city tour and welcome reception will also be included. Payment is required by August 21, 2023. The fee for payments after this date is 660 €. Arrangements for registration and payment are posted on the Summer School website.

### Accommodation
Participants are asked to make their own reservations. Rooms are pre-reserved for participants at some Student Hostels and Hotels around the venue of the Summer School. More detailed information about reservation modalities, including a list of accommodations is available on the Summer School website.

### Organization
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**10th Summer School on Biomechanics of Soft Tissues: From the Heart to the Cardiovascular System to the Brain**

Graz University of Technology  
Austria  
September 11-15, 2023

Summer School coordinated by
Gerhard A. Holzapfel  
Graz University of Technology, Austria  
Ray W. Ogden  
University of Glasgow, UK

WEBSITE:  
www.summerschool.tugraz.at

Image created by D Haspinger
Objectives

This is the 10th Summer School on Biomechanics that we have organized in the series that started in 2001. The aim is to provide an up-to-date overview of biomechanical modeling, simulation and experimental methods on different length scales.

The lectures will include some essential ingredients of continuum mechanics, especially nonlinear elasticity. The focus is on the mechanical and structural modeling of fiber-reinforced materials, including collagen fiber dispersion with the inclusion of collagen cross-links and residual stresses. Applications to artery walls in health and disease such as aneurysms and aortic dissections will be illustrated. Lectures will also cover cardiac biomechanical modeling, touching on the nonlinear anisotropic and viscoelastic nature of the myocardium, the synthesis and integration of these concepts into whole-organ models, and the assimilation of image-based data for patient-specific modeling. Advanced topics on modeling the entire cardiovascular system, hemodynamics, engineered heart tissue and modeling will also be discussed. Vascular adaptation during disease and treatment will be discussed along with measurements of strain fields using imaging techniques and digital image correlation in soft tissues. The important area of parameter identification will be covered by full-field optical measurements using the virtual fields method in elasticity.

Another focus will be brain mechanics, including the unusual response of brain tissues and axons under loads, the shaping of the brain and skull during development, and the study of brain trauma and diseases. It will be shown that the gyrification patterns occurring in the human brain are the result of elastic instabilities. Finally, and most importantly, all participants will receive the code, datasets, and documented examples for brain, skin, and arteries, and may bring their own stretch-stress data for analysis.

Future directions and challenges will be identified in lectures for research in multiscale biomechanics and mechanobiology involving mechanical, biological, electrical and fluid-structure interactions.

Invited Lecturers

Stéphane Avril
Mines Saint-Étienne, France
Parameter identification using full-field optical measurements; digital image/volume correlation; optical coherence imaging; virtual fields method; elastography; vascular remodeling and adaptation; mechanics of VSMCs; tensional homeostasis; mechanobiology of aneurysms; computer modeling of endovascular aneurysm repair

Alain Goriely
University of Oxford, UK
Brain modeling; brain tissue and mechanics; neuromechanics; shaping of the brain and skull during development; axonal rheology; nonlinear inelasticity; morphogenesis; ageing; brain trauma and disease; multiphase theory; contact mechanics

Gerhard A. Holzapfel
Graz University of Technology, Austria
Main aspects of mechanical/structural modeling of biological soft tissue; identification of collagen fiber dispersion and associated modeling, including fiber recruitment and damage – pros/cons; modeling/simulation aspects of aortic dissection; negative Poynting effect and its connection with collagen cross-links

Ellen Kuhl
Stanford University, USA
Automated discovery of models, parameters, and experiments for soft tissues; from continuum mechanics to constitutive artificial neural networks; comparing invariant and principal-stretch based networks; Bayesian networks, uncertainty quantification; discovering models, parameters, and experiments for brain, skin, and arteries

David Nordsletten
University of Michigan, USA
Cardiac biomechanics; patient-specific modeling; image-based modeling; model personalization; data assimilation; biomechanics of engineered heart tissues; fractional viscoelasticity; numerical methods; finite element methods; hemodynamic modeling; fluid-structure interaction; elastography; relative pressure estimation

Ray W. Ogden
University of Glasgow, UK
Continuum mechanics required for application to soft biological tissue constitutive modeling; fiber-reinforced materials, fiber dispersion, cross-linking; importance of residual stresses and their influence on the elastic response of arteries; modeling errors to be avoided

Preliminary Suggested Readings


R Miller, E Kerfoot, C Mauger, TF Ismail, AA Young, DA Nordsletten. An implementation of patient-specific biventricular mechanics simulations with a deep learning and computational pipeline. Front Physiol, 1398, 2021


Download these papers, and some more, from the website: www.summerschool.tugraz.at/objectives