Timetable

Time	Monday September 3	Tuesday September 4	Wednesday September 5	Thursday September 6	Friday September 7
08:00 - 09:00	Registration				
09:00 - 09:45	Holzapfel	Gefen	Ogden	Holmes	Wirtz
09:45 - 10:30	Wirtz	Holzapfel	Holmes	Holmes	Kuhl
Break					
11:00 - 11:45	Gefen	Kuhl	Gefen	Gefen	Ogden
11:45 - 12:30	Kuhl	Kuhl	Gefen	Wirtz	Holzapfel
Lunch					
14:30 - 15:15	Ogden	Wirtz	Kuhl	Holzapfel	
15:15 - 16:00	Ogden	Wirtz	Wirtz	Holzapfel	
Break					
16:30 - 17:15	Holmes	Ogden	Presentations of Participants*	Presentations of Participants*	
17:15 - 18:00	Holmes	Holmes			

*Participants are encouraged to present their work, ask questions and stimulate discussion. Please send a title of the presentation to bettina.strametz@tugraz.at by August 15.

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 proteins, soft tissues and organs.

Registration

The registration fee is 595 €. The fee covers the attendance at all lectures, and a book of lecture notes. In addition, light refreshments and snacks will be provided in the morning and afternoon breaks; a guided city tour with a subsequent welcome reception are also included.
Payment is required by July 31, 2018. 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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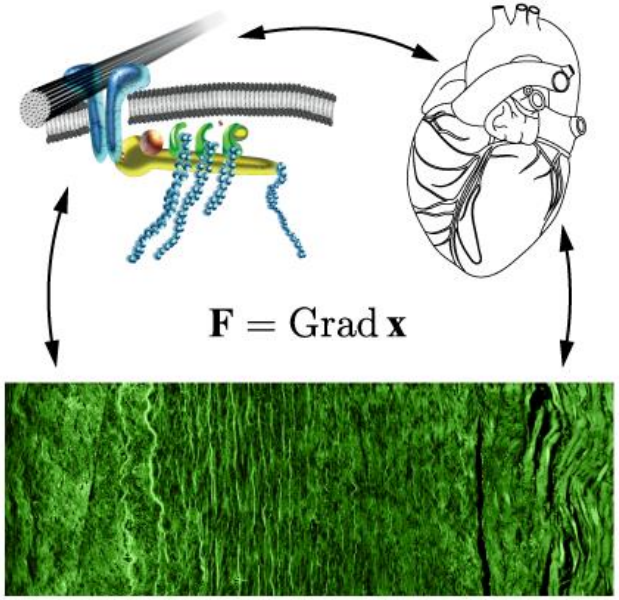
8th Summer School on

BIOMECHANICS, FROM PROTEIN TO TISSUE TO ORGAN: MODELING AND COMPUTATION



GRAZ UNIVERSITY OF TECHNOLOGY AUSTRIA

SEPTEMBER 3 – 7, 2018

Summer School coordinated by

Gerhard A. Holzapfel
Graz University of Technology, Austria

Ray W. Ogden
University of Glasgow, UK

WEBSITE:
www.summerschool.tugraz.at

Objectives

This Summer School on Biomechanics is the 8th in the series and aims to present a state-of-the-art overview of biomechanics, from protein to cell to tissue to organ with related modeling and computation, and their applications. The lectures will cover constitutive modeling of soft tissues such as arteries in health and disease, including aortic dissections, abdominal aortic aneurysms and different approaches to modeling the microstructure. Models of heart, brain and adipose tissues will be examined in comparison with experimental data. We will also include aspects of the mechanics of skin and wound healing, the cytoskeleton and biomolecules. Mechanical signaling and the mechanochemical basis of morphogenesis will also be discussed. Measurements conducted by widely used methods of cell mechanics, including atomic force microscopy and particle-tracking microrheology, will be presented, analyzed, and critically compared. Basic concepts of molecular mechanics and polymer physics relevant to the microrheology response of cells will be featured. A particular focus will also be placed on the presentation of nonlinear continuum mechanics and the finite element method, with applications in biomedical engineering.

Important elements of continuum mechanics will be provided since they constitute a starting point for the characterization of the mechanical properties of soft biological tissues. Particular emphasis will be placed on the theory of elasticity, experimental data and models of individual biomolecules, networks of proteins, living cells and organs. Also experimental techniques for the determination of the mechanical properties of cellular components and cells will be presented. Attention will also be focused on the modeling and simulation of the mechanics, chemo-mechanics and electrophysiology of proteins, cells, artery walls, the heart, the brain, adipose tissue and skin.

Throughout the course the lecturers will point to future directions and challenges in research in the broad area of biomechanics at multiple scales, and mechano-biology as well as phenomena that involve mechanical, biological and chemical interactions.

Invited Lecturers

Amit Gefen
Tel Aviv University, Tel Aviv, Israel

Mechanobiology and models for wounds and wound healing; mechanics of adipocytes, adipose tissue and mechanobiology of obesity; mechanical modeling of cells; skin-related cell-level modeling; injury biomechanics; biomechanical aetiology of pressure ulcers; human body protection; clinical biomechanics

Jeffrey W. Holmes
University of Virginia, USA

Heart function; myocardial infarction; myocardial material properties; biaxial mechanical testing; anisotropy; compartmental models; agent-based models; finite-element models; growth and remodeling

Gerhard A. Holzapfel
Graz University of Technology, Austria

Introduction to soft tissue biomechanics; arterial wall mechanics; aortic dissection; abdominal aortic aneurysm; second-harmonic generation imaging; modeling of non-symmetric fiber dispersion; discrete fiber dispersion model; failure criteria for arteries; arterial fracture

Ellen Kuhl
Stanford University, USA

Brain tissue; neurodevelopment/degeneration; neuro-mechanics; neurosurgery; axonal growth; diffuse axonal injury; traumatic brain injury; chronic traumatic ence-phalopathy; craniosynostosis; nanoindentation; elastography; personalized simulations

Ray W. Ogden
University of Glasgow, UK

Essential ingredients of continuum mechanics, with an emphasis on nonlinear elasticity; constitutive modeling of fiber-reinforced materials and fiber dispersion; residual stresses and their influence on material response, with particular reference to arteries

Denis Wirtz
Johns Hopkins University and
Johns Hopkins School of Medicine, USA

Cell mechanics, molecular mechanics, polymer physics, nanorheology, measurement methods for cell properties, atomic force microscopy, particle-tracking microrheology, cancer cells, cell cortex, nucleus, cytoplasm

Preliminary Suggested Readings

GM Fomovsky, AD Rouillard, JW Holmes. Regional mechanics determine collagen fiber structure in healing myocardial infarcts. *J Mol Cell Cardiol*, 52:1083-1090, 2012

A Gefen and D Weihs. Cytoskeleton and plasma-membrane damage resulting from exposure to sustained deformations: A review of the mechanobiology of chronic wounds. *Med Eng Phys,* 38:828-833, 2016

A Goriely, S Budday, E Kuhl. Neuromechanics: from neurons to brain. *Adv Appl Mech*, 48:79-139, 2015

O Gültekin, H Dal, GA Holzapfel. Numerical aspects of anisotropic failure in soft biological tissues favor energy-based criteria: A rate-dependent mixed crack phase-field model. *Comput Meth Appl Mech Eng*, 331:23-52, 2018

GA Holzapfel, JA Niestrawska, RW Ogden, AJ Reinisch, AJ Schriefl. Modelling non-symmetric collagen fibre dispersion in arterial walls. *J R Soc Interface*, 12:20150188, 2015

RW Ogden. Nonlinear continuum mechanics and modelling the elasticity of soft biological tissues with a focus on artery walls, in GA Holzapfel and RW Ogden (eds), “Biomechanics: Trends in Modeling and Simulation”, Springer, p. 83-156, 2016

D Raz-Ben Aroush … D Wirtz, P-H Wu. Comparative study of cell mechanics methods, *Nat Methods*, in press

WJ Richardson, SA Clarke, TA Quinn, JW Holmes. Physiological implications of myocardial scar structure. *Compr Physiol*, 5:1877-1909, 2015

N Shoham, A Levy, N Shabshin, D Benayahu, A Gefen. A multiscale modeling framework for studying the mechanobiology of sarcopenic obesity. *Biomech Model Mechanobiol*, 16:275-295, 2017

J Weickenmeier, CAM Butler, PG Young, A Goriely, E Kuhl. The mechanics of decompressive craniectomy: Personalized simulations. *Comp Meth Appl Mech Eng*, 314:180-195, 2017

D Wirtz. Particle-tracking microrheology of living cells: principles and applications. *Annu Rev Biophys*, 38:301-326, 2009

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