TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	September 6	September 7	September 8	September 9	September 10
9.00 - 9.45	Registration	Fratzl	Reilly	Duda	Reilly
9.45 - 10.30	van Rietbergen	Fratzl	Reilly	Duda	Reilly
11.00 - 11.45	Klein-Nulend	Müller	Müller	Fratzl	Fratzl
11.45 - 12.30	Klein-Nulend	Müller	Müller	Fratzl	Fratzl Q&A
14.00 - 14.45	Reilly	van Rietbergen	Klein-Nulend	van Rietbergen	
14.45 - 15.30	Reilly	van Rietbergen	Klein-Nulend	van Rietbergen	
16.00 - 16.45	Duda	Klein-Nulend	Duda	Müller	
16.45 - 17.30	Duda	Klein-Nulend Q&A	Duda Q&A	Müller Q&A	
18.00	Welcome Aperitif				

ADMISSION AND ACCOMMODATION

The registration fees are:
- Participation in presence, 600.00 Euro + VAT*
This fee includes a complimentary bag, four fixed menu buffet lunches (on Friday upon request), hot beverages, downloadable lecture notes.
- Participation online, 250.00 Euro + VAT*
This fee includes downloadable lecture notes.

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through the following web site: http://www.cism.it. A message of confirmation will be sent to accepted participants. Applicants requiring assistance with the registration should contact the secretariat at the following email address: cism@cism.it.

Applicants may cancel their course registration and receive a full refund by notifying CISM Secretariat in writing (by email to cism@cism.it) no later than two weeks prior to the start of the course.

Cancellation requests received during the two weeks prior to the start of the course will be charged a 50.00 Euro handling fee. Incorrect payments are also subject to a 50.00 Euro handling fee.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered lodging and/or board, if available, in a reasonably priced hotel or student guest house.

Requests should be sent to CISM Secretariat by **July 6, 2021** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

Information about travel and accommodation is available on the web site www.cism.it, or can be mailed upon request.

* where applicable (bank charges are not included)
Italian VAT is 22%.

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ACADEMIC YEAR 2021
The Shinozuka Session
Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

BONE CELL AND TISSUE MECHANICS

Advanced School
coordinated by

Bert van Rietbergen
Eindhoven University of Technology
The Netherlands

Udine ***September 6 - 10*** **2021**

BONE CELLS AND TISSUE MECHANICS

Bone is a remarkable material: it is strong yet lightweight, can adapt itself to changes in mechanical loading, lasts for a lifetime and can repair itself after a fracture. Although biology has revealed many secrets of how bone cells can form and remove bone tissue, the mechanisms that control these processes, and the role of mechanical loading in this, are still not well understood. The goal of this course is to provide state-of-the-art information on this topic. To do so, the course will review the entire area of bone cell and tissue mechanics at all three commonly distinguished levels of structural organization of bone: the bone organ level, the bone tissue level and the bone cell level. The course will be of a multi-disciplinary nature and include topics like bone biology, imaging and computational modeling.
At the bone organ level, the focus will be on the diagnosis of bone strength using imaging and computational techniques. Bone remodeling at this level is often considered as an optimization process that adapts bone density and shape to the mechanical loading conditions. Hypothetical models that are developed to describe such adaptations of bone are discussed. At the tissue level, bone can form remarkable complex porous architectures. This capability enables bone to adapt to a wide range of mechanical conditions, as reflected by a wide spectrum of architectures and material properties bone can take on. Methods to visualize and model the complex structures of this living mineral tissue in 3D in-vivo have become available only over the last two decades. Hypothetical models describing how these structures evolve, how they can adapt to mechanical loading and how they can be affected by bone diseases are discussed.
At the level of the cell, promising candidates for the mechanosensory system will be discussed, as well as possible signaling pathways for the communication between bone cells. At this level, the porosity of the bone tissue itself also becomes an important factor since it is assumed that fluid flow plays an important role in the mechanosensory system. Recently developed techniques for visualizing such small structures, as well as techniques for stimulating and manipulating cells, such as microfluidics devices for bone cell mechanobiology studies, 3D printing of bone stimulating implants, and tissue engineering of bone to create humanized 3D models are discussed.
Besides being informative, it is hoped that the course will function as a forum for the exchange of data, philosophy, and ideas across disciplinary divides and so provide further stimulus for a comprehensive approach to the problems of bone mechanics. To further facilitate this, we will organize a student poster-pitch presentation at the end of the first day. Also, there will be a question and answers session at the end of all other days where students can ask questions to the teachers, and where the teachers will stimulate discussions. The target audience are graduate students, PhD candidates and young faculty members. We expect an audience as diverse in background as the lecturers, that is to say spanning across the professional spectrum from biomedical and structural engineers, to biologists, veterinarians and orthopaedic and dental surgeons.

PRELIMINARY SUGGESTED READINGS

Cowin, S.C. and Doty, S.B., Tissue Mechanics, Springer, 2007.

Gefen, A. (editor) Cellular and Biomolecular Mechanics and Mechanobiology, Springer, 2011.

Jacobs, C.R. Introduction to Cell Mechanics and Mechanobiology, Garland Science, 2012.

Silva, M.J. (editor) Skeletal Aging and Osteoporosis: Biomechanics and Mechanobiology, Springer, 2012.

Doblaré, M. and Merodio J. (editors) Biomechanics, Eolss Publishers, 2015.

Pivonka, P. (editor) Multiscale Mechanobiology of Bone Remodeling and Adaptation, CISM International Centre for Mechanical Sciences, 2018.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.

INVITED LECTURERS

Georg Duda - Julius Wolff Institut & Berlin-Brandenburg Center for Regenerative Therapies Charité - Universitätsmedizin Berlin, Germany
5 lectures on: bone tissue formation and repair.
In-vivo loading; bone mechano-adaptation in aged; principles of bone regeneration; from mechanical forces to tissue straining - how biophysical cues can be used to guide regeneration; exploit the immune-structure interface for bone regeneration.

Peter Fratzl - Max Planck Institute of Colloids and Interfaces, Research Campus Golm, Potsdam, Germany
5 lectures on: bone mineralization and fracture resistance.
Multi-scale structure of bone; mechanisms of deformation and fracture of bone; bone mineralization kinetics; mineral distribution and its dynamics; bone mineral in osteoporosis.

Jenneke Klein Nulend - ACTA-University of Amsterdam and Vrije Universiteit Amsterdam, The Netherlands
5 lectures on: bone biology and bone cell mechanosensitivity.
Cells and tissues; bone cells; bone growth and remodeling; osteocyte mechanosensing; histomechanics of cell biology and bone remodeling.

Ralph Müller - ETH Zürich, Switzerland
5 lectures on: bone imaging down from the molecules, to the cells, tissue and up to the organ.
Hiierarchical bone functional imaging; in-vivo bone tissue and cell imaging; dynamic imaging; local in vivo environment (LivE) imaging; imaging in tissue engineering and regeneration.

Gwendolen Reilly - The University of Sheffield, UK
6 lectures on: creating loading environments for bone cells and tissues.
Traditional animal and cell culture models of bone loading; high magnitude/low frequency and vibration loading; cell mechanobiological processes modulated by substrate stiffness; 3D printing of bone stimulating implants; tissue engineering for humanized 3D models; microfluidics for bone cell mechanobiology.

Bert van Rietbergen - Eindhoven University of Technology, The Netherlands
4 lectures on: the quantification of bone structure, strength and adaptation, with a strong focus on analysis of human bone in-vivo.
Bone structural imaging and quantification; bone strength measurement and computation; bone adaptation measurement and prediction; state-of-the-art of bone strength and adaptation.