

TIME TABLE

TIME	Monday June 4	Tuesday June 5	Wednesday June 6	Thursday June 7	Friday June 8
9.00 - 9.45	Registration	Redaelli	Redaelli	Lim	Spatz
9.45 - 10.30	Buehler	Redaelli	Redaelli	Lim	Spatz
11.00 - 11.45	Ballarini	Buehler	Lim	Spatz	Ballarini
11.45 - 12.30	Ballarini	Buehler	Lim	Spatz	Ballarini
14.00 - 14.45	Bausch	Lim	Spatz	Ballarini	
14.45 - 15.30	Bausch	Lim	Spatz	Ballarini	
16.00 - 16.45	Bausch	Bausch	Buehler	Redaelli	
16.45 - 17.30	Bausch	Bausch	Buehler	Redaelli	

ADMISSION AND ACCOMMODATION

Applicants must contact CISM Secretariat at least one month before the beginning of the course. Application forms should be sent on-line through our web site: <http://www.cism.it> or by post.

A message of confirmation will be sent to accepted participants. If you need assistance for registration please contact our secretariat.

The 700,00 Euro registration fee includes a complimentary bag, four fixed menu buffet lunches (Friday not included), hot beverages, on-line/downloadable lecture notes and wi-fi internet access.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered board and/or lodging in a reasonably priced hotel. Requests should be sent to CISM Secretariat by **April 4, 2012** 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 our web site, or can be mailed upon request.

For further information please contact:

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 Piazza Garibaldi 18
 33100 Udine (Italy)
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Centre International des Sciences Mécaniques
 International Centre for Mechanical Sciences

ACADEMIC YEAR 2012
 The Cercignani Session



MATERIOMICS: MULTISCALE MECHANICS OF BIOLOGICAL MATERIALS AND STRUCTURES

Advanced School
 coordinated by

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 MN, USA

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Massachusetts Institute of Technology
 Cambridge
 MA, USA

Udine, June 4 - 8, 2012

MATERIOMICS: MULTISCALE MECHANICS OF BIOLOGICAL MATERIALS AND STRUCTURES

Multiscale mechanics of hierarchical materials plays a crucial role in understanding and engineering biological and bioinspired materials and systems. The mechanical properties of engineering materials have been studied extensively, and changed our world by enabling the design of complex structures and advanced devices. The mechanical science of hierarchical tissues and cells in biological systems has recently emerged as an exciting area of research and provides enormous opportunities for innovative basic research and technological advancement. Such advances could enable us to provide engineered materials and structures with properties that resemble those of biological systems, in particular the ability to self-assemble, to self-repair, to adapt and evolve, and to provide multiple functions that can be controlled through external cues.

However, despite significant advancements in the study of biological materials in the past decade, the fundamental physics of many phenomena in biology continue to pose substantial challenges with respect to model building, experimental studies, and simulation. Specifically, the understanding of the mechanisms of failure in biological systems remains a major issue, in particular in the context of breakdown of tissue in disease states, the failure of biological components due to injuries, and the ability of biological systems to mitigate adverse effects of damage through self-healing mechanisms. Because of our lacking ability to engineer biological materials, we also remain hindered in our ability to mass produce and utilize these materials for daily life applications, through consumer products, medical devices and

large-scale systems in aerospace, defense and building technologies. The hierarchical bottom-up design approach in biology, from the level of genes (DNA), to proteins, to tissues, organs and organisms, originates at the molecular scale and requires a bottom-up description from a fundamental perspective. For this reason, approaches rooted in physics that consider the structure-process-property paradigm of materials science are a powerful means to investigate the properties of biological materials, a new field of study referred to as materiomics.

The aim of this course is to present lectures from leading researchers in the field of mechanical sciences of biological materials and structures, with a focus on the behavior of biological materials under extreme physical, chemical as well as physiological

conditions and human disease, as well as on biomimetic and bioinspired material development for technological applications. To provide a thorough foundation for this research, the course will focus on the integration of advanced experimental, computational and theoretical methods applied to the study of biological materials, across disparate length- and time-scales, from nano to macro. A particular focus of this course will be the discussion of theoretical, computational and experimental tools utilized to assess structure-process-property relations and to monitor and predict mechanisms associated with the function and failure of biological materials and structures composed of them. The lectures will provide an overview over emerging fields in this broad field of research and outline important challenges and opportunities.

INVITED LECTURERS

Roberto Ballarini - University of Minnesota, Minneapolis, MN, USA
6 lectures on: Performance indices of biological structures, fracture mechanics of and experiments on biological structures and materials at the nano, micro and macro scales.

Andreas Bausch - Technische Universität Muenchen, Germany
6 lectures on: Experimental methods in biological molecules and materials. Single molecule mechanics: Theory and Experiment. Cytoskeletal proteins: Physics of semiflexible polymers. Viscoelasticity of actin networks: Linear response/nonlinear response. Viscoelasticity of actin networks: linear response.

Markus J. Buehler - Massachusetts Institute of Technology, Cambridge, MA, USA
5 lectures on: Multiscale science of protein materials in extreme conditions and disease; molecular modeling and simulation, multi-scale modeling, bionanomechanics. Introduction to materiomics.

Chwee Teck Lim - National University of Singapore, Singapore
6 lectures on: Introductory cell mechanics and mechanobiology. Experimental techniques in cell & molecular mechanics. Biomechanics approaches to studying human diseases.

Alberto Redaelli - Politecnico di Milano, Italy
6 lectures on: Biomechanics of tissues (blood vessels, blood flow, etc.), multi-scale modeling of microtubules, tissue engineering.

Joachim Spatz - Max Planck Institute for Intelligent Systems, Stuttgart Germany
6 lectures on: Introduction to experimental cell biology. Cell-materials interactions: Introduction and case studies. Nanoscience at the interface to biology.

PRELIMINARY SUGGESTED READINGS

Ashby, M.F., L.J. Gibson, U. Wegst and R. Olive, The mechanical properties of natural materials. I. Material property charts. Proc. R. Soc. Lond. A, Vol. 450, pp. 123-140, 1995.

Bausch, A.R., K. Kroy, Cytoskeleton from the assembly line: a bottom-up approach to cell mechanics. Nature Physics, Vol. 2 (4), pp. 231-238, 2010.

Kamat, S., X. Su, R. Ballarini and A.H. Heuer. Structural basis for the fracture toughness of the shell of the conch *Strombus gigas*. Nature Vol. 405, pp. 1036-1040, 2000.

White, S.R., N.R. Sottos, P.H. Geubelle, J. S. Moore, M.R. Kessler, S.R. Sriram, E.N. Brown and S. Viswanathan, Autonomic healing of polymer composites. Nature Vol. 409, pp. 794-797, 2001.

Wegst, U.G. M.F. Ashby, The mechanical efficiency of natural materials, Philosophical Magazine Vol. 21, pp. 2167-2181, 2004.

Köhler, S., V. Schaller and A.R. Bausch, Structure formation in active networks. Nature materials, Vol. 10, pp. 462-468, 2011.

Lim, C.T., E.H. Zhou, S.T. Quek. Mechanical models for living cells - A review, Journal of Biomechanics, Vol. 39, pp. 195-216, 2004.

Lim, C.T., E.H. Zhou, A. Li, S.R.K. Vedula, H.X. Fu. Experimental techniques for single cell and single molecule biomechanics, Materials Science and Engineering C: Biomimetic and Supramolecular Systems, Vol. 26(8), pp. 1278-1288, 2006.

Deville, S., E. Saiz, R.K. Nalla and A.P. Tomsia, Freezing as a path to build complex composites, Science Vol. 311, pp. 515-518, 2006.

Lee, G.Y.H., C.T. Lim. Biomechanics approaches to studying human diseases, Trends in Biotechnology, Vol. 25(3), pp. 111-118, 2007.

Buehler, M.J., Y. Yung, Deformation and failure of protein materials in extreme conditions and disease, Nature Materials, Vol. 8(3), pp. 175-188, 2009.

Shen, Z.L., M.R. Hodge, H. Kahn, R. Ballarini and S.J. Eppell, In-Vitro Fracture Testing of Submicron Diameter Collagen Fibrils Under Uniaxial Testing, Biophysical Journal Vol. 99, pp. 1986-1995, 2010.

Cranford, S., M.J. Buehler, Materiomics: Biological Protein Materials, from Nano to Macro, Nanotechnology, Science and Application, Vol. 3, pp. 127-148, 2010.

Tang, Y., R. Ballarini, M.J. Buehler and S.J. Eppell. Deformation micromechanisms

of collagen fibrils under uniaxial tension. Journal of the Royal Society Interface, Vol. 7, pp. 839-850, 2010.

Knowles, T., M.J. Buehler, Nanomechanics of functional and pathological amyloid materials, Nature Nanotechnology, Vol. 6(7), pp. 469-479, 2011.

Spivak, D., T. Giesa, E. Wood, M.J. Buehler, Category theory analysis of hierarchical protein materials and social networks, PLoS ONE, Vol. 6, paper # e23911, 2011.

Mireille, M.A.E. Claessens, Christine Semmrich, Laurence Ramos, Andreas R. Bausch. Helical twist controls the thickness of F-actin bundles. Proceedings of the National Academy of Sciences USA, Vol. 105, pp. 8819-8822, 2010.

Schaller, V.C. Weber, C. Semmrich, E. Frey and A.R. Bausch. Polar Patterns of driven Filaments. Nature, Vol. 467, pp. 73-77, 2010.

LECTURES

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

**MATERIOMICS: MULTISCALE MECHANICS OF BIOLOGICAL
MATERIALS AND STRUCTURES**

Udine, June 4 - 8, 2012

Application Form

(Please print or type)

Surname _____

Name _____

Affiliation _____

Address _____

E-mail _____

Phone _____ Fax _____

Method of payment upon receipt of confirmation (Please check the box)

The fee of Euro 700,00 includes IVA/VAT tax and excludes bank charges

I shall send a check of Euro _____

*Payment will be made to CISM - Bank Account N° 094570210900,
VENETO BANCA - Udine (CAB 12300 - ABI 05035 - SWIFT/BIC VEBHIT2M -
IBAN CODE IT46 N 05035 12300 09457 0210900).
Copy of the receipt should be sent to the secretariat*

*I shall pay at the registration counter with check, cash or VISA
Credit Card (Mastercard/Eurocard, Visa, CartaSi)*

**IMPORTANT: CISM is obliged to present an invoice for the above sum. Please
indicate to whom the invoice should be addressed.**

Name _____

Address _____

C.F.* _____

VAT/IVA* No. _____

(* Only for EU residents or foreigners with a permanent business activity in Italy.)

Only for Italian Public Companies

I ask for IVA exemption (ex law n. 537/1993 - art. 14 comma 10).

Privacy policy: I understand that data received via this form will be used only to provide information about CISM and its activities, within the limits set by the Italian legislative decree no. 196/2003 and subsequent amendments.

Complete information on CISM's privacy policy is available at http://www.cism.it/courses/privacy_statement/

I have read the "Admission and Accommodation" terms and conditions and agree.

Date _____ Signature _____