TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	August 31	September 1	September 2	September 3	September 4
9.00 - 9.45	Registration	Suo	McMeeking	Forde	Bernheim
9.45 - 10.30	McMeeking	Suo	McMeeking	Forde	Bernheim
11.00 - 11.45	Suo	Bacca	Suo	Bernheim	Forde
11.45 - 12.30	Suo	Bacca	Suo	Bernheim	Forde
14.00 - 14.45	Lucantonio	McMeeking	De Simone	Forde	
14.45 - 15.30	Lucantonio	McMeeking	De Simone	Forde	
16.00 - 16.45	Bacca	Lucantonio	Poster Session	Bernheim	
16.45 - 17.30	Bacca	Lucantonio	Poster Session	Bernheim	
18.00	Welcome Aperitif				

ADMISSION AND ACCOMMODATION

The registration fee is 600.00 Euro + VAT*, where applicable (bank charges are not included). The registration fee includes a complimentary bag, four fixed menu buffet lunches (on Friday upon request), hot beverages, downloadable lecture notes and wi-fi internet access.

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 1, 2020** 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.

* Italian VAT is 22%.

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ACADEMIC YEAR 2020
The Shinozuka Session
Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

MECHANICS OF SMART AND BIO-HYBRID GELS: EXPERIMENTS, THEORY, NUMERICAL SIMULATION

Advanced School
coordinated by

Mattia Bacca
University of British Columbia
Vancouver, Canada

Alessandro Lucantonio
Scuola Superiore Sant'Anna
Pisa, Italy

Udine ***August 31 - September 4*** 2020

MECHANICS OF SMART AND BIO-HYBRID GELS: EXPERIMENTS, THEORY, NUMERICAL SIMULATION

The proposed course aims at creating a bridge between mechanics, chemistry, physics and biology to educate new scientists in the new and fast growing scientific framework of active soft matter. Many health treatments involving drug delivery and tissue transplant technology rely on a deep understanding of the physiological conditions of the living tissue involved. To achieve this, one needs to account for the coupling between the mechanical behavior of the tissue and its biochemical activity at multiple length scales, from intracellular mechanisms to tissue behavior at the organ level. In this framework, most of the scientific problems require cross-disciplinary expertise to be tackled, hence the emerging need for a new generation of scientists capable of combining fundamental concepts from different disciplines.
The course is aimed at researchers and graduate students in the fields of applied mathematics, mechanical and chemical engineering, physics, biology and biophysics.
Dr. Zhigang Suo will introduce the concept of hydrogel. Polymeric gels constitute a reliable physical model platform for most of the soft biological tissue constituting the human body hence this represents the foundation of this course. He will provide basic insight on the main mechanical properties of these materials such as adhesive strength, fracture toughness, fatigue resistance and viscoelasticity.
Dr. Alessandro Lucantonio will discuss the analytical and computational tools available today to describe the mechanical behavior of gels with particular focus on their poroelastic behavior, which couples elasticity of the polymer network and species diffusion.
Dr. Mattia Bacca will discuss the thermodynamics of active deformation for materials depicted as a microstructural evolution. The phenomenon emerges from a biochemical process, the activity of molecular motors powered by ATP hydrolysis, which alter the equilibrium state of the material, resulting in (active) macroscopic deformation.
Dr. Robert McMeeking will discuss the mechanics and thermodynamics of actin polymerization occurring within the cytoskeleton and the mechanics of cell adhesion. This will highlight the active and anisotropic characteristics of the material constituting living cells.
Dr. Antonio De Simone will provide an introduction of fundamental concepts on crawling and deformation driven locomotion of living systems. This will link the motility of a cell with its biochemical activity at the molecular level (actin-myosin, microtubule-dynein).
Dr. Nancy Forde lectures will provide insight into experimental techniques for characterization soft matter and measure molecular-scale phenomena. She will then provide theoretical and practical insight on micro rheology, single- molecule mechanics and other techniques to create synthetic molecular motors.
Finally, Dr. Anne Bernheim will provide insight into the theory and the experimental techniques utilized to recreate other cell-level mechanisms with in-vitro system and will conclude the course.

PRELIMINARY SUGGESTED READINGS

W. Hong, X. Zhao, J. Zhou, Z. Suo (2005) “A theory of coupled diffusion and large deformation in polymeric gels” Journal of the Mechanics and Physics of Solids 56 1779-1793.

A. Lucantonio, P. Nardinocchi, L. Teresi (2013) “Transient analysis of swelling-induced large deformations in polymer gels” Journal of the Mechanics and Physics of Solids 61 205-218.

M. Bacca, O.A. Saleh, R.M. McMeeking (2018) “Contraction of polymer gels created by the activity of molecular motors” Soft Matter 15 4467-4475.

V.S. Deshpande, R.M. McMeeking, A.G. Evans (2006) “A bio-chemo-mechanical model for cell contractility” Proceedings of the National Academy of Sciences - USA 103 14015-14020.

G. Noselli, A. Beran, M. Arroyo, A. DeSimone (2019) “Swimming euglena respond to confinement with a behavioural change enabling effective crawling” Nature Physics 179 799-805.

M.W.H. Kirkness, K. Lehmann, N.R. Forde (2019) “Mechanics and Structural Stability of the Collagen Triple Helix” arXiv:1903.07276.

A. Bernheim-Groswasser, N. Gov, S. Safran, N. Tzlil (2018) “Living matter: mesoscopic active materials” Advanced Materials 30 1707028.

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

Mattia Bacca - University of British Columbia, Vancouver, Canada
4 lectures on: Continuum mechanics and thermodynamics of active soft materials
1. Non-equilibrium thermodynamics of the continuum; 2. State variables and microstructure evolution of materials; 3. Energy transduction and chemo-mechanics of materials; 4. Contraction of an active gel.

Anne Bernheim - Ben-Gurion University of the Negev, Be'er Sheva, Israel
6 lectures on: In-vitro reconstitution of the contractile cytoskeleton
1. In vitro system as a model for reconstituting cellular processes; 2-3. Actin based motility driven by actin polymerization; 4. Active gels - self-organization and patterning; 5. Actomyosin gels - contractility and poroelasticity; 6. Spontaneous 3D shape transitions of contractile actomyosin gel sheets.

Antonio De Simone - MathLab, SISSA, Trieste, Italy
2 lectures on: Systems of motors and bio-filaments and their role in cell motility
1. Dyneins and microtubules in eukaryotic cilia and flagella; 2. Shape programming in biological and artificial systems.

Nancy Forde - Simon Fraser University, Burnaby, Canada
6 lectures on: Mechanical properties of biological systems at the nano- and micro-scale
1. (Bio)Polymer mechanics - theory and experiment; 2. Single-molecule mechanics techniques; 3. DNA mechanics; 4. Microrheology - experimental approaches; 5. Collagen mechanics - from molecules to the matrix; 6. Synthetic molecular motors.

Alessandro Lucantonio - The BioRobotics Institute, Scuola Superiore Sant’Anna, Pisa, Italy
4 lectures on: Theoretical and computational modeling of polymer gels
1. Introduction to polymer physics and review of coupled models for swelling gels; 2. Asymptotic analysis of transient and steady swelling phenomena; 3. Poroelastic fracture in gels; 4. Finite element formulation of the coupled model and applications.

Robert M. McMeeking - University of California Santa Barbara, Santa Barbara, USA
5 lectures on: Cell contractility and adhesion
1. Acto-myosin stress fibres and cell adhesion; 2. Biochemomechanical mechanisms of contractility; 3. Model of contractility/signaling interactions and in vitro behavior; 4. Interaction of cells with compliant substrates; 5. Modeling in vivo behavior.

Zhigang Suo - Harvard University, Cambridge, MA, USA
6 lectures on: Hydrogels
1. Hydrogel ionotronics and bioelectronics; 2. Tough hydrogels; 3. Fatigue of hydrogels; 4. Stretchable materials of high toughness and low hysteresis; 5. Hydrogel adhesion; 6. Poroelasticity of hydrogels.