Second GEM^4 Summer School on

CELL AND MOLECULAR MECHANICS IN BIOMEDICINE

with a focus on Cancer

(in conjunction with the GEM^4 Conference on Cancer 2007)

June 25 - July 6, 2007
National University of Singapore

www.gem4.org

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Summer school website: www.gem4.org/summerschool2007
GEM^4 Conference on Cancer website: http://www.gem4.org/cancer2007

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Summer School or ganization

This two-week long summer school will be the second in the series, following the successful inaugural summer school held at MIT in August 2006 (with a focus on infectious diseases). Strong laboratory experience and exposure to local research facilities will be provided in addition to introductory and advanced tutorials.

Organized by:

GEM^4

Local organization:

National University of Singapore (NUS)

Scientific Program & Organizing Committee:

Chair:	C.T. Lim (NUS)
Co-chair:	K.S.W. Tan (NUS)
Members:	Y. Ito (NUS)
	P. Macary (NUS)
	C.N. Ong (NUS)
	C.H. Sow (NUS)
	Patrick Tan (Duke-NUS Graduate Medical School & Genome Institute of Singapore, A*STAR)

International Advisory Committee:

S. Suresh (Chair)	MIT, USA
G. Bao	Georgia Institute of Technology, USA
D.E. Discher	University of Pennsylvania, USA
Barry Halliwell	NUS, Singapore
R. D. Kamm	MIT, USA
G. Milon	Institut Pasteur Paris
T. Saif	University of Illinois at Urbana-Champaign, USA
W. Schowalter	NUS, Singapore
Michael P. Sheetz	Columbia University, USA

Summer school venue:

Centre for Life Sciences (CeLS), NUS

Fees:

Fees per participant: S$3,200.00 (overseas), S$1,000.00 (local)

(Fees include lunches, refreshments, 2-week accommodation (overseas participants only) & attendance at the GEM^4 Conference on Cancer (http://www.gem4.org/cancer2007))

Registration:

For registration, please visit www.gem4.org/summerschool2007/registration.html

Overall Organizational support:

GEM4 Secretariat, National University of Singapore
B.V.R. Chowdari (chowdari@gem4.org)

Summer course organizational contact: Maureen Oliveiro (gemoma@nus.edu.sg)

Summer School Dates

Period:

25 June to 6 July 2007

Total Duration:

8 days

The summer school will comprise 5 full days (25 – 29 June 2007) and 6 half-days (30 June and 2 – 6 July 2007). For 2 – 6 July 2007, the participants will attend the morning plenary lectures at the GEM^4 Conference on Cancer and resume classes in the afternoons. On 30 June 2007, there will be a social outing in the evening.

Proposed Course T opics & Lectur ers/ Instructors

The following is a tentative course outline of the topics for both cancer biology and cellular and molecular biomechanics. For the biology components, participants will be exposed to a broad range of topics encompassing the physiology, cell and molecular biology, immunology, basic biology of cancer, cancer diagnosis and treatment. Advances in nanotechnology and their applications to diagnosis and therapy will also be discussed.

Topics of Interest:

1. **Introduction to Physiology**
2. **Introduction to Cell Biology**
3. **Introduction to Molecular Biology**
4. **Introduction to Immunology**
5. **Origin of cancer**
   - Cell structure and functions
   - The nature of Cancer
   - Tumour progression and metastasis
6. **Genetic aspects of cancer**
   - Cancer inheritance
   - Oncogenes and Tumour suppressor genes
   - Multistep carcinogenesis
7. **Cancer immunity and prevention**
   - The immune system and cancer
   - Cancer chemoprevention
   - Cancer vaccines
   - Immunotherapy of cancer (monoclonal antibodies, cytokines etc.)
8. **Cancer Therapy**
   a. Drugs targeting cancer cells
      - Use of stem cells
      - Nanoparticles

   b. Chemotherapy

   c. Molecular approach to cancer therapy

   d. Nanotherapeutics - Innovative application of nanotechnology to gene, immuno-, and cell therapy
9. **Cancer detection and Diagnostics**
   a. Biomarkers for early detection

   b. Bioimaging

c. Genomics and proteomics:
   - Microarrays
   - 2-dimensional electrophoresis

d. New approaches:
   - Nanotechnological probes – quantum dots, nanoshells, gold nanoparticles

10. Cell & Molecular Biomechanics:

a. Basic mechanics
   - Stress & strain
   - Elastic, plastic and viscoelastic response

b. Continuum & statistical mechanics

c. Molecular biomechanics
   - Brief introduction to molecular biomechanics
   - Polymer chains, statistics of random walks, persistence length,
   - Boltzmann distribution, freely jointed chain, worm-like chain model
   - Protein conformational dynamics, the role of force in protein-protein
   - Motor molecules and protein nanomachines
   - Motility at the macromolecular level, polymerization forces

d. Cell Biomechanics
   - Cell membrane mechanics
   - Cytoskeletal structure and motility
   - Time dependent responses, CSK mechanics
   - Cell adhesion, receptor-ligand interaction, focal adhesions
   - Measurement of cell adhesive forces and kinetics
   - Microrheology
   - Generalized Stokes-Einstein relationship (GSER)
   - Force-fluctuations inside cells, active processes, and breakdown of GSER
   - Nonequilibrium dynamics; evidence for a glassy domain

e. Tissue Biomechanics
   - Elastic and viscoelastic response of connective tissues
   - Poroelasticity; Darcy's Law; Hydraulic Permeability

f. Computational Biomechanics
   - Molecular modeling and simulation
   - Continuum modeling of the cell
   - Multi-scale cell modeling

g. Case studies on cell & molecular biomechanics and its connection to cancer

h. Space, time and energy landscapes mechanobiology
   - Introduce basic interactions: steric, electrostatic, vdw, hbond, hphobic

- Macromolecular surface forces: electrostatic double layer, DLVO, surface tension, etc.
- kT as ruler of molecular forces
- Self-assembly as a result of competing molecular forces
- Thermal forces and Brownian motion
- Random walk
- Meaning of the Central Limit Theorem
- Diffusion vs Langevin equation descriptions ('Average' vs 'Individual')
- Diffusion coefficient and fluctuation-dissipation theorem
- Reaction kinetics
- Michaelis-Menten kinetics
- Arrhenius relation
- Binding energy/affinity
- Classical equilibrium picture vs stochastic picture of rate processes
- Cooperativity
- Mechanostransduction: Biological relevance in the context of cell migration, sensing and force generation

i. Experimental methods

- Optical stretcher, optical tweezers, molecular force probes
- AFM imaging and force spectroscopy
- Magnetic trap
- 3D microscopy — deconvolution, confocal, 2-photon
- Micropipette aspiration & dual pipette assay
- Mcrofluidics

j. Lab Sessions:

- Cell & tissue culture lab
- Multi-photon confocal microscopy
- Optical trap: DNA & cells
- Magnetic tweezers
- Microfluidics: cancer cell
- AFM: Live cell & DNA imaging
- AFM: Force spectroscopy
- Micropipette aspiration
- Dual pipette assay
- Cell stretching
- Anti-metastasis
- Cytotoxicity

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List of Speakers & Instructors (in alphabetical order)

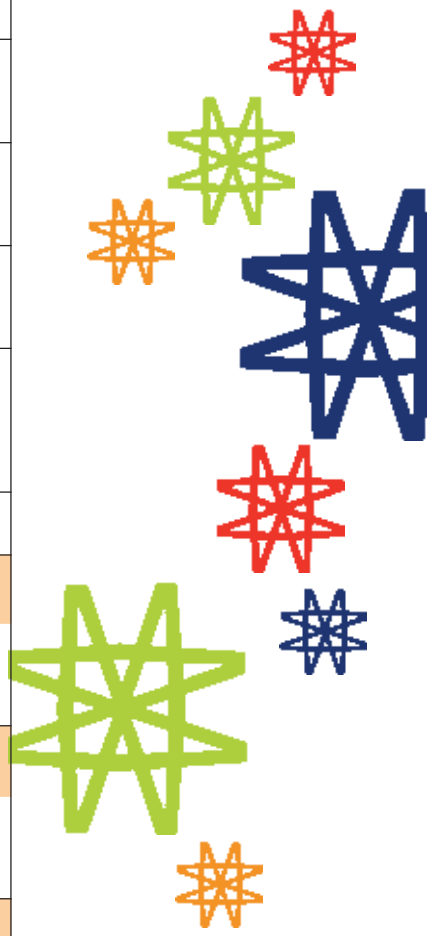
Speakers	Affiliation
Markus J. Buehler	MIT
Jianzhu Chen	MIT
Maxey Chung	National University of Singapore
Kevin D. Costa	Columbia University
Ming Dao	MIT
Dennis E. Discher	University of Pennsylvania
Cheng Dong	Penn State University
S.S. Feng	National University of Singapore
Huajian Gao	Brown University
Morteza Gharib	California Institute of Technology
Nir Gov	The Weizmann Institute of Science
John Groopman	Johns Hopkins University
Ed Guo	Columbia University
Mingyong Han	Institute of Materials Research & Engineering, A*STAR
Yoshiaki Ito	National University of Singapore
Yan Jie	National University of Singapore
Roger D. Kamm	MIT
Matthew J. Lang	MIT
Norbert Lehming	National University of Singapore
Kam W. Leong	Duke University
Ju Li	Ohio State University
C.T. Lim	National University of Singapore
Paul MacAry	National University of Singapore
Marc Meyers	University of California, San Diego
Daniel Müller	Technische Universität Dresden
Choon Nam Ong	National University of Singapore
Shazib Pervaiz	National University of Singapore
Gunaretnam Rajagopal	Bioinformatics Institute, A*STAR
G. Ravichandran	California Institute of Technology
J.N. Reddy	Texas A&M University & National University of Singapore
Robert O. Ritchie	University of California, Berkeley
Taher Saif	University of Illinois at Urbana-Champaign
Manuel, Salto-Tellez	National University of Singapore
Ram Sasisekharan	MIT
Thomas Seufferlein	University of Ulm School of Internal Medicine
Michael P. Sheetz	Columbia University
Peter So	MIT
M. Sokabe	Nagoya University
C.H. Sow	National University of Singapore
Joachim Spatz	Max-Planck Institute & University of Heidelberg
Subra Suresh	MIT
Kevin Tan	National University of Singapore
Patrick Tan	Genome Institute of Singapore, A*STAR
Vincent B.C. Tan	National University of Singapore
Jean Paul Thiery	Institute of Molecular and Cell Biology, A*STAR

Instructors

Monica Diez (GEM^4), Christian Franck (Caltech), B.R. Hairul Nizam (NUS), Gabriel Lee (Singapore-MIT Alliance), Ang Li (NUS), Q.S. Li (NUS), John P. Mills (MIT), Maxim Shusteff (MIT), Manoj K Puthia (NUS), David Quinn (MIT), E.P.S. Tan (NUS), S.J. Tan (NUS), S.R.K. Vedula (NUS), Yinjing (NUS)

Tentative Summer School Schedule

Date/Day	Time	Activity
24 Jun 07 (Sun)		**Arrival / Check-in** **Prince George's Park Residences (PGPR) Dormitory**
Day 1 25 Jun 07 (Mon)	0800 – 0830 0830 – 1230 1230 – 1330 1330 – 1730 1800 – 2000	**Registration** **Welcome Address** **Basic Mechanics** Lunch Break (Foyer) **Introduction to Physiology** Evening Mixer
Day 2 26 Jun 07 (Tue)	0830 – 1230 1230 – 1330 1330 – 1730	**Continuum & Statistical Mechanics** Lunch Break (Foyer) **Introduction to Cell Biology**
Day 3 27 Jun 07 (Wed)	0830 – 1230 1230 – 1330 1330 – 1730	**Molecular Mechanics** Lunch Break (Foyer) **Introduction to Molecular Biology**
Day 4 28 Jun 07 (Thu)	0830 – 1230 1230 – 1330 1330 – 1730	**Space, time and energy landscapes in mechanobiology** Lunch Break (Foyer) **Introduction to Immunology**
Day 5 29 Jun 07 (Fri)	0830 – 1230 1230 – 1330 1330 – 1730	**Experimental Methods** Lunch Break (Foyer) **Lab Demonstrations**
Day 6 30 Jun 07 (Sat)	0830 – 1230 1230 – 1330 1330 – 1730 1730 onwards	**Tissue Mechanics** Lunch Break (Foyer) **Lab Demonstrations** Social Outing
1 Jul 07 (Sun)		GEM4 Conference Registration
Day 7 2 Jul 07 (Mon)	0830 – 1200 1200 – 1315 1400 – 1530 1530 – 1600 1600 – 1730	GEM4 Conference Plenary Lecture Lunch Break (Conference Site) **Cell Mechanics** Coffee Break (Foyer) **Computational Biomechanics**
Day 8 3 Jul 07 (Tue)	0830 – 1200 1200 – 1315 1400 – 1530 1530 – 1600 1600 – 1730	GEM4 Conference Plenary Lecture Lunch Break (Conference Site) **Origin of cancer** Coffee Break (Foyer) **Genetic Aspects of Cancer**
Day 9 4 Jul 07 (Wed)	0830 – 1200 1200 – 1315 1400 – 1530 1530 – 1600 1600 – 1730	GEM4 Conference Plenary Lecture Lunch Break (Conference Site) **Cancer Immunity & Prevention** Coffee Break (Foyer) **Cancer Therapy**
Day 10 5 Jul 07 (Thu)	0830 – 1200 1200 – 1315 1400 – 1730 (with 15min coffee break)	GEM4 Conference Plenary Lecture Lunch Break (Conference Site) **Cancer Detection and Diagnostics**
Day 11 6 Jul 07 (Fri)	0830 – 1200 1200 – 1315 1400 – 1730	GEM4 Conference Plenary Lecture Lunch Break (Conference Site) **Cell & molecular biomechanics and its connection to cancer (Case Studies)** Summer School Adjourns



Acknowledgements

The Organizing Committee would like to acknowledge the partial support for the GEM^4 summer school from member institutions, NUS, GEM^4 secretariat, NUS Graduate School for Integrative Sciences and Engineering (NGS), NUS Office of Life Sciences, and US National Science Foundation. We would also like to thank the speakers and instructors for volunteering their time and effort to teach in this summer school.

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About GEM⁴

GEM⁴ will bring together researchers and professionals in major institutions across the globe with distinctly different, but complementary, expertise and facilities to address significant problems at the intersections of select topics of engineering, life sciences, technology, medicine and public health.

GEM⁴ will create new models for interactions across scientific disciplinary boundaries whereby problems spanning the range of fundamental science to clinical studies and public health can be addressed on a global scale through strategic international partnerships.

Through initial focus areas in cell and molecular biomechanics, and environmental health, in the context of select human diseases, GEM⁴ will create a global forum for the definition and exploration of grand challenges and scientific studies, for the cross-fertilization of ideas among engineers, life scientists and medical professionals, and for the development of novel educational tools.

Institutions Participating in GEM⁴

- California Institute of Technology
- Columbia University
- Chulabhorn Research Institute
- Duke University
- Georgia Institute of Technology
- Harvard University
- Institut Pasteur
- Johns Hopkins University
- Massachusetts Institute of Technology
- Max-Planck Institute
- National University of Singapore
- University of California
- University of Illinois at Urbana-Champaign
- Weizmann Institute of Science

GEM⁴ Organization Structure

Subra Suresh (Director)
Ford Professor of Engineering
Massachusetts Institute of Technology, USA

B.V.R. Chowdari (Executive Coordinator)
Department of Physics
National University of Singapore, Singapore

Steering Committee

Subra Suresh (Chair)
Ford Professor of Engineering
Massachusetts Institute of Technology, USA

B.V.R. Chowdari (Executive Coordinator)
Department of Physics
National University of Singapore, Singapore

Gang Bao
Biomedical Engineering
Georgia Institute of Technology and Emory University, USA

Mory Gharib
Division of Engineering and Applied Science
California Institute of Technology, Pasadena, USA

Barry Halliwell
Department of Biochemistry
National University of Singapore, Singapore

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L. Mahadevan
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Geneviève Milon
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Institut Pasteur, Paris, France

Taher Saif
Department of Mechanical Engineering
University of Illinois at Urbana-Champaign, USA

Leona Samson
Center for Environmental Health Sciences
Massachusetts Institute of Technology, USA

Invited Guest Members of the Steering Committee

John Essigmann
Department of Chemistry and Biological Engineering Division
Massachusetts Institute of Technology, USA

Ram Sasisekharan
Biological Engineering Division
Massachusetts Institute of Technology
and Momenta Pharmaceuticals, USA

Geert Schmidt-Schoenbein
Department of Bioengineering
University of California, USA

William Schowalter
Senior Advisor to the President
National University of Singapore, Singapore

Joachim Spatz
Max-Planck Institute, Stuttgart and
University of Heidelberg, Germany