

European Science Foundation
Standing Committee for Physical and Engineering Sciences (PESC)

ESF PESC EXPLORATORY WORKSHOP

**Physics of the Cell: From Single
Molecules to Collective Behaviour**

Scientific Report



Barcelona, Spain, 29 November - 1 December 2006

Convened by:
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Departament de Física Fonamental, Universitat de Barcelona

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1. Executive summary

The main goal of the workshop was to bring together biologists and physicists who are interested in the understanding of the physical processes controlling cell biomolecules' functioning, as well as their collective behavior. The workshop concentrated on cell processes which take place at different length scales, and will emphasize their relationships. The topics of the workshop have hence focused on the following subjects: single molecule experiments, molecular motors, biological membranes, cytoskeleton mechanics and protein folding. The workshop has identified emerging topics in these areas. It has brought together active groups across Europe in the various fields of this interdisciplinary subject, generating a forum for open and stimulating discussions.

The workshop took place in the premises of the Physics faculty of the university of Barcelona. We made use of the rooms that the Faculty has for general meetings, together with auxiliary rooms to favor exchanges among researchers at smaller scale. We also made use of the services provided by the Faculty, such as wireless connection, white and blackboards, etc. Despite being inside a building with additional activities, the size of the group and the location of the rooms (a bit aside of main lecture rooms and Department offices) ensured a close contact among participants during the duration of the event. Lunches were organized in a restaurant nearby but away from the rest of university canteen. We arranged a separate space, so that the contact among participants would not be affected. Also coffee breaks were arranged specifically for the workshop.

Whenever possible, participants have stayed in residences close to the Faculty. Communication with the city center is very good, so it was not a problem for them to move around the city after the workshop in case they were interested.

The workshop was organized in two days and a half and the presentations grouped in five sessions. Each session had a general theme, but the different presentation within each topic have been complementary. There has been an effort to emphasize new experimental techniques and experimental results both in single molecules and in cell processes. Time has been allocated after each presentation to ensure that a lively and informal discussion takes place along the workshop. This environment has helped to promote an open exchange of ideas.

A total of 33 participants contributed to the workshop, coming from nine different countries. The profile of the attendee is a young scientist who has established recently his/her research group and therefore the participants are mostly in an expanding period.

2. Scientific content of the event

The workshop has been devoted to the physical properties of processes which take place inside the cell. It has covered both the physical properties of biomolecules as well as how they integrate to give rise to different intracellular processes.

The approach of the workshop discussed the possibility of developing general frameworks based on a set of basic properties and principles that can allow to predict and foresee other processes.

The contributions addressed the properties of biomolecules, and how to use new techniques to address them, the biological aspects of proteins (such as cadherin) and their mechanical properties, the use of native properties of proteins to predict their behavior, single molecule force measurements on lysosome, the properties of allosteric mechanisms and the biological relevance of allostery both on simple models and on relevant biomolecules, the structural properties of histone-DNA complexes and their equilibrium properties, the mechanical behavior and the elasticity of viral capsids, the mechanical properties of cytoskeletal networks and their implications in motility, the dynamics of molecular assemblies on cellular membranes, the response of membranes to external forcing, the collective dynamics of molecular motors and the use of experiments of motility assays to control the motion of biofilaments on functionalized surfaces, new achievements in the development of optical tweezers among others.

The sessions were balanced between experimental and theoretical presentations and also combined complementary approaches to the study of biological processes and the relevance of physical mechanisms in them.

3. Assessment of the results, contribution to the future direction of the field

The workshop led to lively debates on the implications of the recent advances in the field, and how the different subfields addressed can interact to make further progress. The debate sessions have served that purpose.

There were lively debates following all the presentations, which has served to favour close relationships between the different researchers.

The discussion sessions served to analyze future strategies in the field. In particular, there seemed to be a consensus in the need to develop focused programs at an European level. Researchers feel that big projects become too bureaucratic and not operative enough. The example of HSF programs was put forward as a scheme that is flexible, competitive, with small administrative burdens. It was mentioned that programs developed have to make confidence on researchers and control the outcomes at the end of the projects as a way to quantify the successfulness of the proposals.

4. Final programme

Wednesday 29 November 2006

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| 13.30-14.00 | <i>Registration</i> |
| 14.00 | <i>Welcome</i> |
| 14.15-14.30 | Presentation ESF representative |
| 14.30-15.00 | E. Evans , Using forward and reverse dynamic force spectroscopy to explore unfolding and refolding transitions in poly-protein domains |
| 15.00-15.30 using AFM | M. Carrion-Vazquez , Nanomechanics of cadherin ectodomain |
| 15.30-16.00 | J. Sancho , Exploring non native protein conformations in the neighbourhood of the native basin |
| 16.00-16.30 molecules | C. Cecconi , Force-induced unfolding of single T4 lysozyme |
| 16.30-17.00 | <i>Coffee break</i> |
| 17.00-17.30 | M. Rief , Mechanics of Protein Folding and Unfolding |
| 17.30-18.00 folding | Y. Kipnis , Linking the allosteric transitions of GroEL with protein |
| 18.00-18.30 | F. Livolant , Chirality and electrostatic effects involved in the supramolecular organisation of nucleosome core particles |
| 18.30-19.00 capsids | D. Reguera , Self-assembly and mechanical properties of viral |
| 19:00-19:30 | |

Thursday 30 November 2006

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| 09.00-09.30 | M. Wang , Stretching, twisting, and unzipping DNA |
| 09.30-10.00 | S. Cocco , Unzipping experiments and the DNA sequence: an inverse random walk problem |
| 10.00-10.30 | A. Imparato , Evaluation of free energy landscapes from single molecule experiments |
| 10.30-11.00 | <i>Coffee break</i> |
| 11.00-11.30 | A. Crut , From Single Motors to Cell Motility |
| 11.30-12.00 | H. Flyjberg , Cell motility as persistent random motion: Theories from experiments |
| 12.00-12.30 | M. Garcia Parajo , High resolution single molecule fluorescence microscopy reveals distinct nm-scale compartmentalization of the cell membrane |
| 12.30-13.00 | T. McLeish , Order through Chaos: Brownian Dynamics in Protein Allostery |
| 13.00-15.00 | <i>Lunch</i> |
| 15.00-15.30 | J. F. Joanny , On the shape of stereocilia |
| 15.30-16.00 | E. Frey , From rubber elasticity to floppy modes: a new kind of elasticity for stiff polymer networks |
| 16.00-16.30 | F. Mackintosh , Active and passive cytoskeletal networks: prestress, active stiffening, and non-equilibrium dynamics |

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|-------------|---|
| 16.30-17.00 | <i>Coffee break</i> |
| 17.00-17.30 | D. Navajas , Mechanical properties of the cytoskeleton |
| 17.30-18.00 | C. Schmidt , A switching motor and a twitching gel: from single-molecule to collective non-equilibrium dynamics |
| 18.00-18.30 | M. Velez , Biofunctionalized surfaces to study bacterial cell division: reconstituting the initial steps in the formation of the septosome |
| 18.30-19.00 | Discussion |

Friday 1 December 2006

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| 09.00-09.30 | R. Gonzalez , Direct observation of allostery during aminoacyl-tRNA selection by the ribosome |
| 09.30-10.00 | T. Lionnet , Real time observation of T4 gp41 helicase reveals a passive unwinding mechanism |
| 10.00-10.30 | J. Helenius , Dynamics of supercoiled DNA revealed by combined optical and magnetic tweezers |
| 10.30-11.00 | <i>Coffee break</i> |
| 11.00-11.30 | S. B. Smith , Miniature Optical Tweezers Instrument Measures Forces in 3 Dimensions |
| 11.30-13.00 | Discussion (on possible) follow-up research activities |
| 13.00-15.00 | <i>Lunch</i> |
| 15.00-15.30 | F. Brochard , Cellular nanotubes: hydrodynamic extrusion |
| 15.30-16.00 | S. Diez , Microtubule-based motor systems: From Cellular Function to Bionanotechnology |
| 16.00-16.30 proteins | P. Bassereau , Model membrane deformations induced by |
| 16.30-17.00 | <i>Coffee break</i> |
| 17.00-17.30 | C. Veigel , Single molecule mechanics of myosin motors using optical tweezers |
| 17.30-18.00 motors | J. Casademunt , Cooperative dynamics of interacting molecular |
| 18.00-18.30 | Discussion and closing |

5. Statistical information on participants (age structure, countries, etc)

Statistics

33 participants

Spain (7)

France (6)

Germany (6)

The Netherlands (2)

Denmark (1)

UK (2)

Italia (3)

Israel (1)

USA (4)

Most of the participants are rather young scientists, we lack information on their detailed age. They have established research groups recently.

6. Final list of participants

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