Research Networking Programmes

Science Meeting – Scientific Report

Scientific report (one single document in WORD or PDF file) should be submitted online within two months of the event. It should not exceed seven A4 pages.

Proposal Title*: *Physics of Living Matter symposium, 8th edition - QuanTissue

Application Reference N°: 4749

1) Summary (up to one page)

The last ten years have seen the emergence of the study of biological systems as Living Matter, thus emphasizing the fact that Biology is an important part of the Physical Sciences. It is in this spirit that we have coined the term "Physics of Living Matter" (PLM) to encompass the challenges that emerge from searching inspiration for the solution of problems posed by Biology in the quantitative and analytical approaches characteristic of Physics, Chemistry and Engineering. This is distinct from Biophysics, the more traditional interface between Physics and Biology, which primarily looks for physical analogies in Biology. This new perspective has stimulated many physicists to focus on Biology and is changing the way biologists approach their problems beyond the traditional mutant based approaches and onto a more measurement and perturbation based perspective. These approaches were part of Cell Biology, though traditionally have had a more biophysical flavour which is complementary to the PLM focus on the behaviour of systems. Thus, where ten years ago these approaches were very much focused on prokaryotes, over the last five years and by the hand of dramatic developments in microscopy and computational sciences, they have been extended to more complex systems e.g development, homeostasis and tissue mechanics.

The PLM series grew eight years ago from an interest to promote the interface between the Life and Physical Sciences in Cambridge and over the years has become a popular annual event that attracts people from outside and even abroad. Over the last two years the Symposium has been organized jointly between the University of Cambridge and University College London as a way of bringing together the communities that exist in these institutions. The Symposium is held over two days and has a central event the Bragg lecture, a special lecture given by a prominent researcher who, like L Bragg, has done much to understand Biology from the perspective of the physical sciences. Amidst previous Bragg lecturers have been S Fraser, W. Baumeister, S. Xie, P. Nurse, A. Murray, U. Alon and R. Brent. In addition we have had a growing poster session and an international list of speakers which have made it a source of inspiration to young researchers and of collaborations for the more advanced ones.

The themes of this years symposium were the cytoskeleton, mechanotransduction, plant morphogenesis and cell population dynamics. The Bragg lecture was given by Prof Wendell Lim.

2) Description of the scientific content of and discussions at the event (up to four pages)

Please find below the abstracts of the invited speakers talks. Poster abstract are also available on request.

EB1 Accelerates Two Conformational Transitions Important for Microtubule Maturation and Dynamics
Sebastian P. Maurer, Gergő Bohner, Nicholas I. Cade, Thomas Surrey. Cancer Research UK, London Research Institute, UK

The dynamic properties of microtubules depend on complex nanoscale structural rearrangements in their end regions. Using a combination of in vitro reconstitution, time-lapse fluorescence microscopy, and sub-pixel-precision image analysis, we have studied the nanoscale distribution of the end tracking protein EB1 in the microtubule end region and its effects on the kinetics of microtubule catastrophes. EB1 density distributions at growing microtubule ends reveal two consecutive conformational transitions in the microtubule end region, which have growth-velocity independent kinetics. EB1 binds to the microtubule after the first and before the second conformational transition has occurred, positioning it several tens of nanometres behind the microtubule end. This property of EB1 can therefore be used to image conformational transitions in growing microtubule ends at the nanoscale by fluorescence microscopy. We also find that EB1 binding accelerates both conformational maturation steps in the microtubule. These activities establish EB1 as a microtubule maturation factor.

Force Scaling in Stress Fibers
Timothée Vignaud, Manuel Théry, CEA Grenoble, France

Production of mechanical forces in cells is as central to many physical behaviors, such as migration, polarization, division and positioning within tissues. It also appeared as critical a regulator of cell physiology, such as cell growth and differentiation. It is therefore intimately coupled to the key steps of tissue morphogenesis and renewal. As cells progress through these steps, they modulate their size and shape. However, how these geometrical parameters affect force production is still unknown. Here we used surface micropatterning on deformable surface to control cell shape and measure the production of traction forces. We focused our attention to the production of forces in actin filament bundles called stress fibers. Nanoablation was used to severe these bundles and measure their specific contribution to the total force production. Thereby we could analyze how force production varies with bundle length.

The Mechanics of Active and Passive Cellular Assemblies: How Biomimetic Reconstitution Can Help to Understand Living Cell
Timo Betz, Institut Curie, Paris, France

Understanding the intriguing complexity of living systems is one of the main driving forces of science. To gain insight we use biomimetic systems that reconstitute well defined cellular assemblies and compare these to the living system. Our main interests are the mechanical properties and the generation of forces, both mediated by the cytoskeleton and its interaction with the plasma membrane. Recent advances allow to mimic structures such as the actin cortex, sparse actin networks and actin bundles, and we use optical tweezers to quantify the mechanical properties of these structures and to compare them to living cells. While sparse actin networks and polymerizing actin bundles show rather passive behaviour, we apply the same measurement methods to living cells such as cell blebs and red blood cells which allow to study the out-of-equilibrium mechanics of these systems, and to determine the timescale at which the system's activity becomes evident.

Pre-committed State of Embryonic Stem Cells Defined by an Auxetic Nucleus
Kevin Chalut, University of Cambridge, UK

Embryonic stem cells (ESCs) self-renew in a state of naïve pluripotency in which they are competent to give rise to all somatic cells. It has been proposed that, in the process of exiting the naïve pluripotent state and becoming irreversibly committed, ESCs must pass through at least one metastable intermediate state. This intermediate, or pre-committed, state would represent a gateway state for differentiation of ESCs and reprogramming of somatic cells. However, the pre-committed state as yet possesses no exclusive definition. As opposed to investigating molecular mechanisms, we sought a phenotype of the pre-committed state by studying the global properties of ESC nuclei. We used atomic force microscopy and microfluidic confinement to investigate how ESC nuclei respond to compression and stretching forces. Using these techniques, we discovered that the nuclei of pre-committed ESCs are auxetic. Auxetic materials, as opposed to most other biological materials that have been studied, increase in thickness upon stretching and decrease in thickness upon compression. Auxetics are an emerging frontier in materials science due to their high capacity for shock absorption and stress stiffening or softening on very short time scales. This auxetic nuclear state was not found in naïve or committed ESCs, and also not in lineage restricted cells: it is unique to the pre-committed nucleus and therefore represents a novel phenotype. The discovery of this unique biophysical phenotype will necessitate a rethinking of the superstructure of the cell nucleus, particularly in ESC differentiation.

Motor-clutch Model for Substrate Stiffness Sensing by Living Cells
David J. Odde, Department of Biomedical Engineering, University of Minnesota, MN, USA

Cells sense the mechanical stiffness of their environment to control cell shape, differentiation, survival, proliferation, and migration. How cells sense the Young’s modulus of an elastic environment to make these vital decisions is not clear. We recently showed that a simple “motor-clutch” model exhibits stiffness sensitivity (Chan and Odde, Science, 2008). In particular, the F-actin retrograde flow rate and traction force exhibit a biphasic response to substrate Young’s modulus, an effect that we confirmed using embryonic chick forebrain neurons. We now further explore the behaviour of the motor-clutch model, and assess which model parameters control the stiffness at which sensing is optimal. Our exploration of parameter space reveals that no single parameter in the motor-clutch model can strongly control the set-point for optimal stiffness sensing. Rather, parameters need to be changed coordinately to effectively change the set-point. In particular, coordinate increases of both motor and clutch numbers effectively increases the set-point stiffness. Our recent experimental studies with glioma cells are consistent with predictions of the motor-clutch model. We speculate that the motor-clutch model may be useful for in silico identification of combination drug targets for brain cancers.

Moving Under Confinement: Pushing off the Walls and Squeezing the Nucleus
Matthieu Piel, Institut Curie, Paris, France

The quest to understand how the mechanical and geometrical environment of cells impacts their behavior and fate has been a major force driving the recent development of new technologies in cell biology research. Despite rapid advances in this field, many challenges remain in order to bridge the gap between the classical and simple cell culture plate and the biological reality of actual tissues. In tissues, cells have their physical space constrained by neighboring cells and extracellular matrix. In the recent years, we have developed simple and versatile devices to specifically study the effect of individual parameters of the cell micro-environment, independently of each other. Such parameters include confinement (lack of space), adhesion and geometry. I will focus on how cells move when they are confined and lack specific adhesion, and on how they can squeeze their nucleus through micrometric constrictions. As highlights of this talk, you will very likely hear about moving sausages and be exposed to the first universal law of cell migration.

Transcription Factors and Nuclear Reprogramming
John B. Gurdon, Gurdon Institute, University of Cambridge, UK

When a somatic cell nucleus is transplanted to an egg, the resulting embryo has undergone major changes in transcriptional activity. This takes place whether a single nucleus is transplanted to a single, unfertilized egg in second meiosis or whether multiple somatic nuclei are transplanted to the progenitor eggs in first meiosis named oocytes. Our interest is in how such big transcriptional changes can take place so fast. This leads on to the question of how a transcription factor can find its definitive binding sequence when there may be only one such sequence in the genome. This problem is important because most transcription factors have a 104 preferred affinity for their own binding site compared to all other random sites. But the other random sites vastly outnumber the definitive binding site. This talk will discuss the various possibilities by which transcription factors can successfully bind their definitive binding site in a nucleus.

A Mechanical Checkpoint Controls Multicellular Growth Through YAP/TAZ Regulation by Actin Capping/Severing Factors
Stefano Piccolo, Department of Molecular Medicine, University of Padua School of Medicine, Italy

Key cellular decisions, such as proliferation or growth arrest, typically occur at spatially-defined locations within tissues. Loss of this spatial control is a hallmark of many diseases, including cancer. Yet, how these patterns are established is incompletely understood. Here we report that physical and architectural features of a multicellular sheet inform cells about their proliferative capacity through mechanical regulation of YAP and TAZ, known mediators of Hippo signaling and organ growth. YAP/TAZ activity is confined to cells exposed to mechanical stresses, such as stretching, location at edges/curvatures contouring an epithelial sheet, or stiffness of the surrounding extracellular matrix. We identify the F-actin capping/severing proteins Cofilin, CapZ and Gelsolin as essential gatekeepers that limit YAP/TAZ activity in cells experiencing low mechanical stresses, including contact inhibition of proliferation. We propose that mechanical forces are overarching regulators of YAP/TAZ in multicellular contexts, setting responsiveness to Hippo, WNT and GPCR signaling.

Measuring Molecular Forces Across Specific Proteins in Living Cells
Brenton Hoffman, Duke University, USA

In vivo, cells adhere to the deformable extracellular matrix (ECM) that is both a source of applied forces and a means of mechanical support. Cells detect and interpret mechanical signals, such as force and rigidity, from the ECM through mechanotransduction. While the connections between cells and the ECM, mediated by structures called focal adhesions (FAs), are primary determinants of mechanotransduction, the molecular mechanisms mediating this process are largely unknown. Progress has been limited by an inability to measure dynamic forces across proteins in living cells. Therefore we developed an experimentally calibrated Forster resonance energy transfer (FRET)-based biosensor that measures forces across specific proteins with pico-Newton sensitivity. The sensor has been applied to vinculin, a critical linker protein in the connections between the integrins and actin filaments whose recruitment to FAs is force-dependent. High tension across vinculin is associated with adhesion assembly and enlargement. Conversely, vinculin is under low force in disassembling or sliding FAs at the trailing edge of migrating cells. These data reveal an unexpected regulatory mechanism in which the ability of vinculin to bear tension determines whether adhesions assemble or disassemble under applied force. Current efforts focus on producing the next generation of molecular tension sensors. The existing sensor is only sensitive to forces ranging from 1-6 pN, and may not be optimal for studying mechanotransduction in diverse contexts, such as highly contractile cells or in vivo environments. To aid design, we have developed a novel calculation scheme based on simple theories from polymer physics. If correct, the rational design of a new class of tension sensors with sensitivities ranging from 0.5-25 pN should be possible. This range is expected to be sufficient for many studies in mechanotransduction. Forces significantly less than 0.5 pN are on the scale of Brownian motion, and likely irrelevant, and forces much larger than 25 pN induce bond rupture (i.e. cadherin or integrin dissociation).

The Design Principles of Cellular Regulatory Networks
Wendell Lim, UCSF, USA

Traditionally, biology has focused on deconstructing and mapping the molecular systems that carryout complex regulatory functions. We still lack, however, a more global understanding of the design principles governing how cells solve problems and make regulatory decisions. To address this problem, we have begun complementing deconstructionist approaches with synthetic approaches in which was ask how to build molecular systems that can execute particular regulatory tasks. Are there a limited number of molecular algorithms that evolution can use to solve common physiological tasks? If so, can we learn to recognize them in order to understand the function of complex cellular networks? We are exploring how by systematically rewiring cellular networks, we can test our understanding of cellular logic, as well as engineer cells that execute novel therapeutic functions.

Auxin, Self-organisation and the Colonial Nature of Plants
Ottoline Leyser, The Sainsbury Laboratory, Cambridge, UK

Plants continuously adjust their body plan to suit the environmental conditions in which they are growing. A good example of this is in the regulation of shoot branching. Axillary meristems, which are established in each leaf formed from the primary shoot apical meristem, can remain dormant as a bud or they can activate to produce a branch. The decision whether or not to activate an axillary meristem involves integration of a wide range of environmental, physiological and developmental factors. An increasing body of evidence suggests that the regulatory system for bud activity centres on the self-organising properties of the systemic transport network for the plant hormone, auxin. We are studying this network and its mode of action, combining molecular biological, physiological and quantitative genetic approaches with computational modelling to understand environmentally responsive shoot branching patterns. For example, we have discovered that the recently identified hormone, strigolactone, modulates shoot branching by systemic modulation of the auxin transport network. The mechanism we propose allows the total number of active buds to be adjusted according to the nutrient status of the plant, without specifying which buds should activate, supporting integration of local and systemic factors in bud regulation.

How to Fold a Plant Tissue?
Olivier Hamant, University de Lyon, France

Changing shape is changing structure. This implies that at any given time point, a shape can be associated with a pattern of mechanical stress. Focusing on the shoot apical meristem in plants, we found that mechanical signals control the orientation of cortical microtubules, which guide the deposition of cellulose and thus control the mechanical anisotropy of plant cell walls. This in turn supports morphogenetic events, such as tissue folding, which further consolidates the stress pattern. Remarkably, this feedback loop also exists at the single cell level, as illustrated in the jigsaw puzzle shape of leaf pavement cells. Furthermore, we found that the microtubule response to stress can promote growth heterogeneity in tissues. We propose that the maintenance of such growth heterogeneity potentiates organogenesis and tissue folding. Prospects for this work are numerous and the impact of stress on cell division and gene expression patterns will notably be discussed in the talk.

Quantifying Growth and the Mechanical Properties of Plant Cells
Richard S. Smith, Max Planck Institute for Plant Breeding Research Cologne, Germany

Morphogenesis results from the regulation of the physical properties of growing cells by genes and signalling networks. To explore these processes, we have developed a new technology called the Cellular Force Microscopy (CFM) to investigate physical properties of plant tissues at the cellular level. The CFM is a highly automated micro-robotics device that can make precise force measurements over a large range of forces and displacements. By combining force measurements with osmotic treatments, we can provide estimates for both turgor pressure and cell wall elasticity in individual cells. Equally important is the quantification of cell shape change and growth at the cellular level, and its relationship with gene expression. For this we have developed a new software called MorphoGraphX (www.MorphoGraphX.org) and have used it to study cell expansion in 3D during the early events of seed germination in Arabidopsis. The results suggest that cell expansion patterns depend on both the spatial extent of gene expression combined with geometric factors inherent in the shape of the tissue. To test this hypothesis, we have built a 3D mechanical simulation of the embryo using the finite element method (FEM).

Life in a Box: The Plant Cell Wall as a Material Controlling Organ Formation
Siobhan Braybrook, The Sainsbury Laboratory, Cambridge, UK

One of the defining features of plant cells is their enclosure within a cell wall. As such, the shape and growth of a plant cell is controlled by changes in cell wall mechanical properties and turgor pressure. All plants cells have cell walls, irrespective of their place within the kingdom; however, there is a marked variability in plant development and cell wall composition. One of our aims is to examine the underlying physical basis for wall-restricted growth, and towards this end we are examining canonical growth systems in many different species to answer the question: are their universal mechanical rules for growth? By examining shape growth, cell wall mechanics, cell wall composition, and molecular/hormonal regulation (when possible) we are finding examples of commonality and disparity in the mechanics of growth within the plant kingdom. Here we will describe one growth system, organ formation at shoot apical meristems resulting from stem cell daughter differentiation.

Feedback between Cell Fate, Cell Movement and Tissue Architecture
Hernán López-Schier, Helmholtz Zentrum Munchen, Germany

Epithelia represent the most common tissue in metazoa. Our recent work on the establishment, maintenance and regeneration of epithelial planar polarity in the mechanosensory lateral line of the zebrafish has resulted is the discovery of a novel tissue-level cellular behaviour that we call "planar cell inversions". Using multispectral in toto live imaging, we four that this remarkable cellular reorganisation takes place immediately after the symmetric division of hair-cell progenitors and results in the perfect alignment of hair cell along the axis of planar polarity in the organ. Planar cell inversion, in combination with an exclusively anisotropic growth of the organ, underlies the formation and homeostasis of epithelial mirror symmetry. We are currently investigating how mechanical forces are transmitted among cell during this tissue remodelling process.

Proteolytic and Physical Mechanisms of Tumor Cell Invasion into Extracellular Matrix
Katarina Wolf, NCMLS Nijmegen, The Netherlands

Tumor cell migration through 3D tissue depends on a physicochemical balance between tissue constraints and deformability of cell and nucleus, respectively, and is further governed by integrin- and actomyosin-mediated traction and contact-dependent ECM degradation mediated by matrix metalloproteinases (MMPs). We here dissect the relative contributions of these parameters under conditions of space confinement. Using MMP-degradable collagen lattices or non-degradable substrates of varying porosity, we quantitatively identify the limits of cell migration by physical arrest. MMP-independent migration declined as linear function of pore size and deformation of the nucleus, with arrest reached at 10% of nuclear cross-sections. Residual migration under space restriction strongly depended upon MMP-dependent ECM cleavage by enlarging matrix pore diameters, and integrin- and actomyosin-dependent force generation, which jointly propelled the nucleus. To examine the effect of overall nuclear deformability on migration rates through spatially confined substrates, lamin A/C was either transiently knocked down or stably overexpressed yielding reduced and enhanced stiffness values of the nucleus, respectively, as detected by atomic force microscopy. Whereas lamin knockdown enhanced migration rates through both collagen lattices and transwell membranes of 15-20 µm2 pore cross sections by 2-fold, equal migration efficacy and thus 'physical rescue' was reached at pore sizes of 50-60 µm2, approximating undeformed nuclear cross sections. Vice versa, tumor cells overexpressing lamin A/C migrated at highly reduced speed through dense lattices which was, again, rescued in substrates with pore sizes matching the nucleus. Thus, the efficacy and limits of interstitial cell migration depend upon scaffold porosity and deformation of the nucleus, with pericellular collagenolysis and mechanocoupling as modulators.

The Membrane-cytosol Interface in the Regulation of the Actin Cytoskeleton
Jenny Gallop, Gurdon Institute, University of Cambridge, UK

The membrane-cytosol interface is the site of assembly of a variety of factors that lead to the reorganization of the actin cytoskeleton. In turn, the actin cytoskeleton mediates important cell biological processes such as cell shape change, cell movement, membrane traffic and cytokinesis. We mimic the membrane-cytosol interface using artificial membranes and extracts from frog eggs and find that the lipid composition and curvature of the membrane influences the proteins that are used to regulate actin polymerization. From flat PI(4,5)P2-containing membranes we see the recruitment of Toca/FBP17 F-BAR-SH3 domain membrane-binding adaptor proteins and Ena/VASP actin filament elongation proteins, and the formation of structures resembling filopodia (finger-like cell protrusions). From curved, PI(3)P and PI(4,5)P2-containing membranes the recruitment of BAR-SH3 adaptor protein Snx9 is important, which localizes to endocytic vesicles in cells. The actin nucleator the Arp2/3 complex and nucleation-promoting factor N-WASP contribute to both modes of actin polymerization. We are investigating the molecular mechanisms underlying membrane-triggered actin polymerization to find out how common actin regulators are used at distinct times and places by cells to make different kinds of actin structure.

3) **Assessment of the results and impact of the event on the future directions of the field (up to two pages)**

The event has been largely over-subscribed, and has attracted participants from all over the UK, with a few delegates from the EU. The attendance was very well balanced between physics and biology, which fits well with the remit of the Symposium. We were also delighted to receive a very large number of poster submissions. We displayed continuously during the conference more than 30 posters and offered a poster price at the end of the two days. The poster sessions were very well attended and have provided a fruitful forum for discussions. The funding received has enabled us to offer a very low registration fee to students (£30); there was as a result a very strong engagement from students and early stage researchers. Excellent feedback was received from attendees and speakers are the conference and after. There is a strong sense that this symposium series plays a pivotal role in establishing a network in Cambridge and London on Physical Biology. We do not have data regarding collaborations that emerged from the meeting, but are confident that multiple connexions have been initiated.

Overall the conference was a great success. We have agreed to repeat this event next year. PLM9 will take place on the 18-19 Sept 2013 in Cambridge. We anticipate a similar size event but plan strengthen the engagement from UCL and a few other institutions from London.

4) **Annexes 4a) and 4b): Programme of the meeting and full list of speakers and participants**

Physics of Living Matters 8 Programme

Thursday, 19th September

13:00 – 13:55 *Registration, coffee and tea reception*
13:55 – 14:00 ***Opening remarks***

Session I: Cytoskeleton - Chair: Kristian Franze

14:00 – 14:30 **Thomas Surrey** (London Research Institute)
EB1 accelerates two conformational transitions important for microtubule maturation and dynamics
14:30 – 15:00 **Manuel Théry** (CEA Grenoble, France)
Force scaling in stress fibers
15:00 – 15:30 **Timo Betz** (Institut Curie, Paris, France)
The mechanics of active and passive cellular assemblies: How biomimetic reconstitution can help to understand living cell
15:30 – 16:00 **Kevin Chalut** (University of Cambridge)
Pre-committed state of embryonic stem cells defined by an auxetic nucleus
16:00 – 16:30 *Coffee / tea break and Poster session*

Session II(a): Mechanotransduction Chair: Anna Philpott

16:30 – 17:00 **David Odde** (University of Minnesota, USA)
Motor-clutch model for substrate stiffness sensing by living cells
17:00 – 17:30 **Matthieu Piel** (Institut Curie, Paris, France)
Moving under confinement: pushing off the walls and squeezing the nucleus
17:30 – 18:00 **John Gurdon** (Gurdon Institute, Cambridge)
Transcription factors and nuclear reprogramming
18:00 – 18:45 *Discussions and posters with drinks reception*

Friday, 20th September

Session II(b): Mechanotransduction Chair: Alfonso Martinez-Arias

9:00 – 9:30 **Stefano Piccolo** (University of Padova, Italy)
A mechanical checkpoint controls multicellular growth through YAP/TAZ regulation by actin capping/severing factors

9:30 – 10:00 **Brenton Hoffman** (Duke University, USA)
Measuring Molecular Forces Across Specific Proteins in Living Cells

10:00 – 11:00 ***Bragg Lecture:*** **Wendell Lim** (UCSF, USA)
The Design Principles of Cellular Regulatory Networks

11:00 – 11:30 Coffee break

Session III: Plant morphogenesis Chair: Dennis Bray

11:30 – 12:00 **Ottoline Leyser** (Sainsbury Laboratory, Cambridge)
Auxin, self-organisation and the colonial nature of plants

12:00 – 12:30 **Olivier Hamant** (University de Lyon, France)
How to fold a plant tissue?

12:30 – 14:00 Lunch break & Poster session

14:00 – 14:30 **Richard Smith** (University of Bern, Switzerland)
Quantifying growth and the mechanical properties of plant cells.

14:30 – 15:00 **Siobhan Braybrook** (Sainsbury Laboratory, Cambridge)
Life in a Box: the plant cell wall as a material controlling organ formation

15:00 – 15:30 Coffee break

Session IV: Cell population dynamics Chair: Alexandre Kabla

15:30 – 16:00 **Hernán Lopez-Schier** (Helmholtz Zentrum München, Germany)
Feedback between cell fate, cell movement and tissue architecture

16:00 – 16:30 **Katarina Wolf** (NCMLS Nijmegen, Netherlands)
Proteolytic and physical mechanisms of tumor cell invasion into extracellular matrix

16:30 – 17:00 **Jenny Gallop** (Gurdon Institute, Cambridge)
The membrane-cytosol interface in the regulation of the actin cytoskeleton

17:00 – 17:15 Closing Remarks

Annex 4b: Full list of speakers and participants

Speakers

Dr Timo Betz	Institut Curie, Paris, France
Dr Siobhan Braybrook	The Sainsbury Laboratory, University of Cambridge
Dr Kevin Chalut	Cavendish Laboratory, University of Cambridge
Dr Jenny Gallop	Gurdon Institute, University of Cambridge
Sir John Gurdon	Gurdon Institute, University of Cambridge
Dr Olivier Hamant	Plant Development and Reproduction Laboratory, ENS, University of Lyon, France
Dr Brenton Hoffman	Department of Biomedical Engineering, Duke University, Pratt School of Engineering, USA
Prof David Odde	Department of Biomedical Engineering, University of Minnesota, USA
Prof Lucas Pelkmans	Institute of Molecular Sciences, University of Zurich, Switzerland
Stefano Piccolo	Institute of Histology and Embryology, University of Padova, Italy
Dr Matthieu Piel	Institut Curie, Paris, France
Prof Ottoline Leyser	The Sainsbury Laboratory, University of Cambridge
Prof Wendell Lim	Department of Cellular and Molecular Pharmacology, Department of Biochemistry and Biophysics, University of California, San Francisco, USA
Dr Hernán Lopez-Schier	Helmholtz Zentrum München, German Research Center for Environmental Health (GmbH), Research Unit Sensory Biology and Organogenesis
Dr Richard Smith	Institute of Plant Sciences, University of Bern, Switzerland
Thomas Surrey	London Research Institute, London, UK
Manuel Théry	Commissariat à l'énergie atomique (CEA), Grenoble, France
Dr Katarina Wolf	Cell Biology, The Nijmegen Centre for Molecular Life Sciences (NCMLS), Nijmegen, The Netherlands

Delegates

Dr Juan Francisco Abenza	University of Cambridge
Dr Sarra Achouri	University of Cambridge
Mr Chibeza Agley	King's College London
Dr Sebastian Ahnert	Cavendish Laboratory- University of Cambridge
Dr Marco Aita	City University London
Mr Peaucelle Alexis	University of Cambridge
Dr Paula Almeida Coelho	Department of Genetics
Dr Gianluca Ascolani	University of Cambridge
Prof Denis Aubry	Ecole Centrale Paris
Dr Clare Baker	University of Cambridge
Prof Buzz Baum	MRC Laboratory for Molecular Cell Biology, UCL
Dr Guy Blanchard	University of Cambridge
Mr Hans Bodart	Laboratoire Matière et Systèmes Complexes, France
Dr Firas Bou Daher	University of Cambridge
Dr Cristina Branco-Price	University of Cambridge
Dr Dennis Bray	PDN, University of Cambridge
Mr Christopher Brimson	University of Bath

Dr Andre Brown	MRC Laboratory of Molecular Biology
Dr Nicolae-Viorel Buchete	University College Dublin
Mr Christoph Budjan	Gurdon Institute / University of Cambridge
Mr Jehangir Cama	University of Cambridge
Miss Eugenia Cammarota	University of Cambridge
Dr Pelin Candarlioglu	Laboratory for Molecular Cell Biology, University College
Miss Danielle Cannon	UCL-MRC-LMCB-CBU
Mr Joseph Chan	Departmet of Physics, University of Cambridge
Mr Qian Cheng	Department of Engineering, University of Cambridge
Miss Wei-Yan Renee Chow	University of Cambridge
Mr Jonathan Chubb	UCL-MRC-LMCB-CBU
Miss Priyamvada Chugh	MRC-LMCB, University College London
Mr Guilherme Correia	Gurdon Institute, University of Cambridge
Mr Adam Corrigan	UCL-MRC-LMCB-CBU
Mr Alex Crick	University of Cambridge
Prof Kevin Dalton	St Catharine's College
Mr Peter Davenport	University of Cambridge
Ms Jessica Davies	UCL
Dr Joaquin de Navascues	University of Cambridge
Dr Giovanna De Palo	Department of Life Sciences, Imperial College London
Prof Jean-Marc Di Meglio	Université Paris Diderot
Mr Andrea Dimitracopoulos	CoMPLEX
Miss Julia Duque	Centro de Biología Molecular "Severo Ochoa"
Mr Jocelyn Etienne	CNRS, Université de Grenoble
Mr Matthew Evans	University of East Anglia
Dr Pedro Farias-Machado	Department of Genetics, University of Cambridge
Dr Kevin Feeney	MRC Laboratory of Molecular Biology
Mr Artur Fernandes	Gurdon Institute, University of Cambridge
Dr Robert Field	JPK Instruments Ltd
Miss Lenka Filipkova	Department of Genetics, University of Cambridge
Dr Cynthia Fisher	University of Cambridge
Prof Makoto Furutani-Seiki	Department of Biology & Biochemistry, University of Bath
Miss Hannah Gaimster	Univeristy of Cambridge
Miss Fernanda Garate	Institut Curie, France
Dr Helene Gautier	University of Cambridge
Miss Annabel Griffiths	Cambridge University
Mr Adrien Hallou	University of Cambridge
Dr Andrew Harris	London Centre for Nanotechnology
Mr Joe Harvey	DAMTP
Dr Penny Hayward	University of Cambridge. Dept. Genetics
Mr Andrew Hodgson	BSS, Department of Physics, University of Cambridge
Dr Wai-Ching Hon	MRC Laboratory of Molecular Biology
Mr Cheng-Kuang Huang	Department of Physics, University of Cambridge
Mr Avelino Javer	University of Cambridge
Mr Joel Jennings	University of Cambridge
Mr Tianrong Jin	University of Warwick
Mr Anton Kan	Department of Plant Sciences, University of Cambridge

Dr Robert Kay	MRC Laboratory of Molecular Biology
Dr Thomas Keller	GlaxoSmithKline R&D
Prof Robert Kennicutt,	University of Cambridge
Miss Nargess Khalilgharibi	London Centre for Nanotechnology, University College
Mr David Koser	University of Cambridge
Miss Maxine Lam	Laboratory for Molecular Cell Biology, University College
Mr Flavio Lanfranconi	University of Zurich
Dr Chiu Fan Lee	Imperial College London
Ms Karolis Leonavicius	St Edmunds Hall, Oxford
Dr Kyriacos Leptos	DAMPT, University of Cambridge
Dr Matthew Levin	University of Cambridge
Dr Catherine Lindon	Department of Genetics
Dr Karen Lipkow	The Babraham Institute
Dr Isaac Liu	University of Warwick
Miss Junyan Liu	Department of Genetics, University of Cambridge
Dr Jonathan Mackenzie	University of Cambridge
Mr Sepehr Mahmoudian	University College London
Mr Vladan Martinovic	MRC Laboratory of Molecular Biology
Dr Ana Mateus	Kings College London
Dr Crystal McClain	University of Cambridge
Dr Nunu Mchedlishvili	MRC Laboratory for Molecular Cell Biology, University College London
Mr Gabriele Micali	Division of Molecular Biosciences, Imperial College London
Miss Agnes Miermont	UCL-MRC-LMCB-CBU
Miss Kate Miller	BP Institute- University of Cambridge
Ms Mingwei Min	University of Cambridge
Miss Stephanie Möllmert	Biotec- TU Dresden
Mr Alexey Morgunov	MRC Laboratory of Molecular Biology
Prof Richard Morris	John Innes Centre
Dr Edward Morrissey	Cambridge Cancer Research UK, University of Cambridge
Dr Silvia Munoz Descalzo	University of Bath
Mr Huw Naylor	Dept of Physiology, Development and Neuroscience, University of Cambridge
Mr Gilbert Ng	Departmet of Physics, University of Cambridge
Dr Jennifer Nichols	SCI- University of Cambridge
Dr Cahir O'Kane	University of Cambridge- Dept of Genetics
Dr Elke Ober	National Institute for Medical Research
Dr Shigekazu Oda	MRC Laboratory of Molecular Biology
Miss Carolin Oefner	Depts of Pathology and Engineering, University of Cambridge
Mr Nikola Ojkic	Imperial College London
Dr Oliver Otto	TU Dresden
Dr Isabel Palacios	Zoology, University of Cambridge
Dr Roy Patterson	University of Cambridge
Miss Marina Peralta	CNIC, Spain
Dr Anna Philpott	Department of Oncology, University of Cambridge
Mr Sean Porazinski	University of Bath
Prof Richard Prager	Department of Engineering, University of Cambridge

Mr Matt Preston	Photometrics and Qimaging, Marlow
Dr Mansoor Raza	Dept. of Physiology Development and Neuroscience, University of Cambridge
Dr Stefanie Reichelt	CRUK Cambridge
Mr Christopher Revell	Cavendish Laboratory, University of Cambridge
Dr Katja Roeper	MRC Laboratory of Molecular Biology
Prof Sir Alan Rowan	Radboud University Nijmegen
Dr Steffen Rulands	University of Cambridge
Miss Kadi Liis Saar	Dept of Chemistry, University of Cambridge
Dr Benedicte Sanson	Dept of Physiology, Development and Neuroscience, University of Cambridge
Dr Thierry Savin	Department of Engineering, University of Cambridge
Dr Max Schlager	MRC Laboratory of Molecular Biology
Dr Christian Schroeter	University of Cambridge
Ms Mirjam Schürmann	TU Dresden
Ms Madeleine Seale	Sainsbury Lab- Cambridge
Dr Marisa Segal	University of Cambridge
Dr Giovanni Sena	Imperial College London
Dr Rajesh Shahapure	University of Cambridge
Dr Graham Sheridan	University of Cambridge
Mr Jason Signolet	Wellcome Trust - MRC Stem Cell Institute
Prof Ben Simons	Departmet of Physics, University of Cambridge
Mr Nishit Srivastava	Department of Engineering
Prof Daniel St Johnston	Gurdon Institute, University of Cambridge
Dr David Summers	Department of Genetics, University of Cambridge
Dr Anna Taubenberger	TU Dresden
Miss Catherine Taylor	The Sainsbury Laboratory,
Miss Katy Taylor	University of Cambridge
Dr Sarah Teichmann	EMBL-EBI
Mr Robert Tetley	University of Cambridge
Ms Amelia Thompson	University of Cambridge
Mr Luke Tweedy	Imperial College London
Dr Elke Ulbricht	Biotec TU Dresden
Dr Jose-Maria Urbano	University of Cambridge
Ms Alex van der Wateren	Department of Chemistry- University of Cambridge
Dr Teresa Vaz Martins	John Innes Centre
Ms Catarina Vicente	The Company of Biologists
Dr Octavian Voiculescu	University of Cambridge
Ms Katrin Wagner	Biotec- Technical University of Dresden
Miss Kirsty Wan	DAMTP, University of Cambridge
Miss Huijia Wang	University of Bath
Mr De-Yao Wang	The Faculty of Life Sciences, the University of Manchester
Dr Lisa Willis	Sainsbury Laboratory- Cambridge University
Dr Alex Winkel	JPK Instruments Ltd
Dr Hugh Woolfenden	John Innes Centre
Mr Tom Wyatt	University College London
Mr George Wylde	BSS, Department of Physics, University of Cambridge
Dr Roberto Zanchi	MRC Laboratory of Molecular Biology