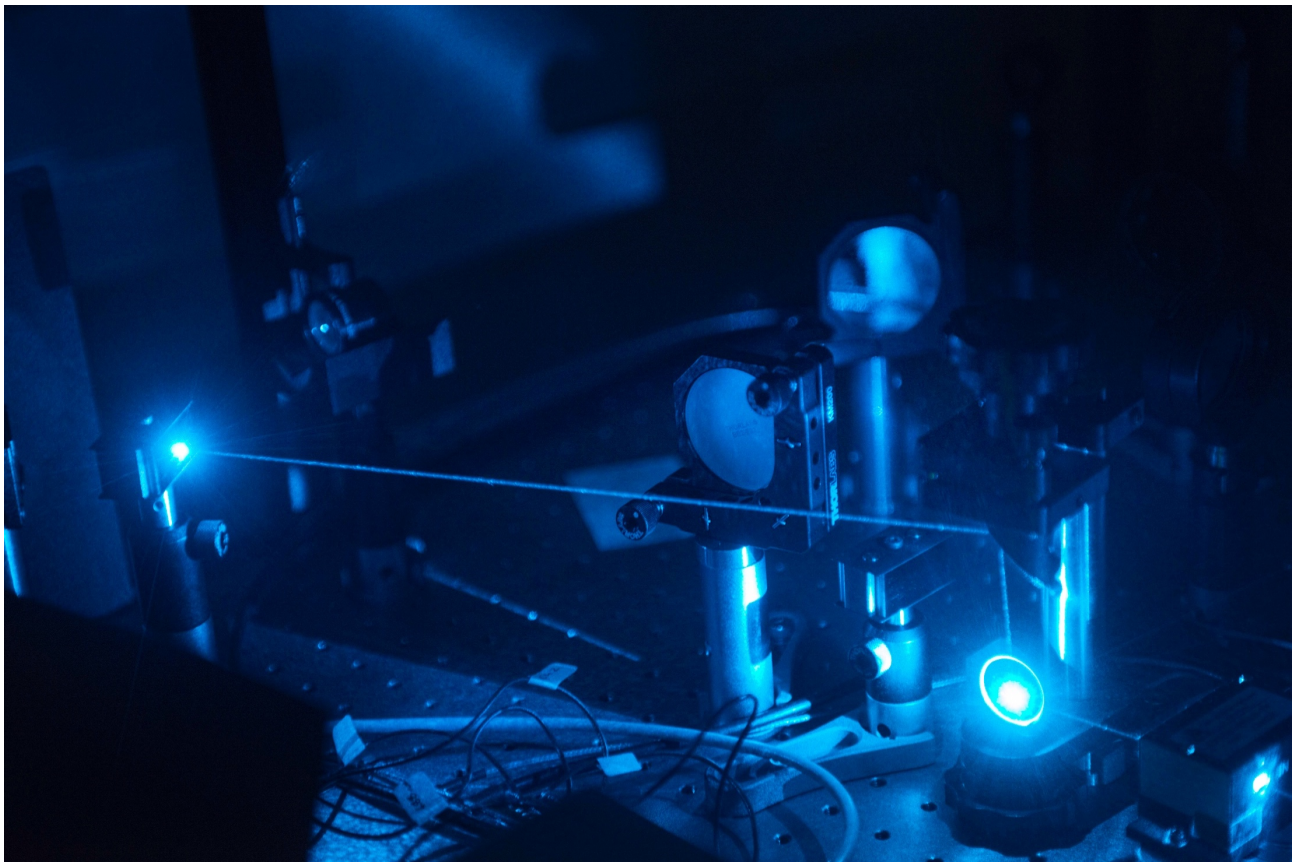
IOP Institute of Physics

Biological Physics Group

NEWSLETTER
April 2018

Issue no. 12



Cover Image: Lasers and optics.

Contents

Items for the newsletter should be e-mailed to m.peckham@leeds.ac.uk

Editorial

In the April edition, we would like to provide the UK biophysics community with an introduction to the new committee (with members old and new). We say a fond farewell to Prof. Jamie Hobbs (our previous chair) and a welcome hello to Prof. Pietro Cicuta (our new chair). There is a meeting report and some news of upcoming meeting. Enjoy reading, and I hope to see you at one of the upcoming conferences!

Professor Michelle Peckham
Newsletter Editor

The Committee

Chair
Pietro Cicuta

Honorary Secretary
Susan Cox

Honorary Treasurer
Tom Waigh

Members
Marisa Martin-Fernandez *(cross representative with national facilities)*
Mark Wallace *(cross representative with BBS)*
Rosalind Allen
Chiu Fan Lee *(responsible for website)*
Ewa Paluch
Michelle Peckham *(responsible for newsletter)*
New members:
Peter Petrov
Achillefs Kapanidis
Bartek Waclaw
Andela Saric

The Chair's commentary

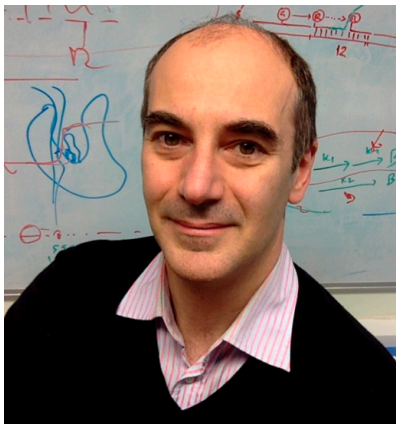
Having played a part in the Biological Physics Group for a while, first as a committee member, then as Treasurer, I am honoured to follow Jamie Hobbs as Chair of the committee. Jamie did a terrific job of organising and directing us, and keeping us well connected to other societies and activities. I hope that I come to this task with a good sense of what the group has worked for in the past, and of the challenges that still face us as we continue to community-build, and the continued need to explain the role of our piece of physics to both our physics and our life sciences colleagues. I wish to continue this work and be as effective as possible in our interventions, which primarily take the form of meetings and communication materials.

New members of the Committee

First of all, many thanks to the members who have just rotated off the committee: Jamie Hobbs as chair, Daniel Robert, Rhoda Hawkins, Christian Soeller. Their contributions towards the group are much appreciated.

Next: Welcome to our new members -
Achillefs Kapanidis, Bartek Waclaw, Peter Petrov andAndela Saric

Achilles Kapanidis



Achilles is a Professor of Biological Physics since 2013; he has also been an ERC grant holder and is currently a Wellcome Trust Investigator. Prof Kapanidis is leading a group of physical and biological scientists (the "Gene Machines" group) which studies microbial biological machinery in gene expression, maintenance, and regulation, with a focus on gene transcription and DNA repair. The main tool of the group is single-molecule fluorescence microscopy. Prof Kapanidis has also been pursuing miniaturized single-molecule imaging, a project that culminated in the formation of the Oxford Nanoimaging spin-out.

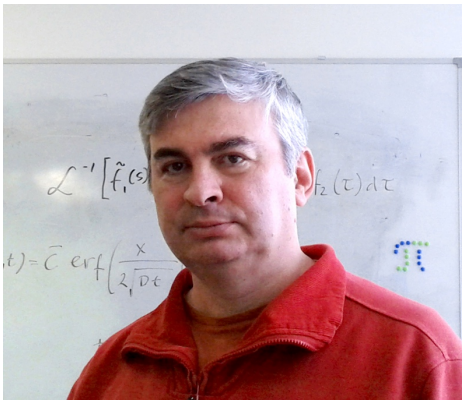
Bartlomiej Waclaw

Bartlomiej received a PhD in theoretical physics in 2007 from Jagellonian University in Krakow. He was a postdoc at Leipzig University for two years before moving to Edinburgh for a second postdoc. He then secured a fellowship from the Leverhulme Trust, followed by a Royal Society of Edinburgh fellowship. In the meantime he was promoted to a proleptic lecturer at the University of Edinburgh.
In the past he has worked on statistical physics problems: random matrix theory, complex networks, random walks, driven diffusive systems, and a few others. Since coming to Edinburgh in 2009, he has been working on applications of statistical and soft matter physics to biological evolution. In particular, he has been studying non-equilibrium phase transitions in models of growing bacterial populations, the structure of fitness landscapes, genetic heterogeneity in cancer, the evolution of antibiotic resistance in bacteria, and the growth of bacterial colonies. Currently, he works on the interplay between molecular mechanisms by which antibiotics kill bacteria and antibiotic resistance spreading in bacterial populations. He also works on experimental and theoretical models of bacterial infections, and on computer models of cancer progression and treatment. Recently, he has become interested in gene regulation and global modulators of transcription. He uses a combination of experiments, computer modelling, and analytical calculations in his research.

Tom Waigh

Tom is a biophysicist who researches biomolecules (peptides and polyelectrolytes) and cells (prokaryotes and eukaryotes). He is interested in biophotonics techniques (e.g. super-resolution fluorescence microscopy, microrheology and optical coherence tomography), X-ray/neutron techniques and develops simple statistical models to describe biophysical phenomena. Current projects include peptide sufactants, antibodies, bacterial biofilms, bacterial communication, bacterial capsules, intracellular motor proteins (dyneins), wound healing, amoeba and elastic turbulence.

Peter Petrov



Peter's research focuses on biophysics of cell membranes in health and disease. Currently his group works on clarifying the effects of oxidative stress on membrane physical properties and biochemical signalling originating in the cell, investigating interactions of pore-forming toxins and immunotoxins with the plasma membrane and transmembrane permeability. Peter also has keen interests in low-Reynolds number hydrodynamics, in particular physics of microswimmers.

Saric Andela

Andela is a Royal Society University Research Fellow at the University College London. She works in the area of computational biological physics, and develops minimal models to study biological assembly and membrane remodelling. She is interested in understanding how proteins assemble into functional nanoscale machinery, far from thermodynamic equilibrium. She is also investigating pathological protein aggregation in the context of amyloid diseases.

Existing members:

Our new Chair: **Pietro Cicuta**

The systems I study with my group, often in collaborations that span locally, UK, EU and farther out, range from gene regulation to cell signalling, from airway pathologies to infectious diseases. There is a strong synergy between the questions we address, and indeed more widely between the disciplines of soft matter physics and biological physics, due to the fact that many experimental techniques and theoretical concepts can be applied to address very different problems. A core technique for example is the development of microfluidic devices and structures for cell control, heading towards high throughput single cell resolution imaging, and organ-on-chip devices. This goes hand in hand with automated microscopy and environmental control for well-defined long-time microscopy video experiments. We have a track record of developing new useful techniques such as optical tweezers, microrheology methods, custom microscopes, advanced confocal microscopy and image analysis algorithms to quantify dynamics both in living cellular and colloidal systems. But what keeps us motivated is usually not the instrument development per se but the mechanisms underlying biological behaviour. The Physics that underpins much of our thinking comes from soft matter physics (liquid interfaces and membranes), statistical mechanics, complex and dynamical systems.

Marisa Martin Fernandez

Marisa Martin-Fernandez was trained as an undergraduate in Physics in Madrid after which she received an international award to do her PhD in the UK. She subsequently won an SERC Post-Doctoral fellowship with Prof. Joan Bordas and a BBRC Post-Doctoral fellowship with Prof. Gareth Jones to develop microscopy techniques to investigate cellular signal transduction mechanisms relevant to cancer. She was appointed Principal Scientist at the Science and Technology Research Council in 2002. Dr. Martin-Fernandez has run an independent research group since 2003 with a continuous focus in developing novel instrumentation and methods to improve our understanding of cancer at the molecular level and to exploit these instruments to derive models of anti-cancer drug-induced behaviour.
Marisa Martin-Fernandez has been recognised with a Research Councils Individual Merit award and a fellowship of the Science and Technology Research Council. She currently heads the Functional Biosystems Imaging group within the Central Laser Facility at the Research Complex at Harwell, which is situated at the Harwell-Oxford Campus, the locus of the large scale scientific infrastructure in the UK.

Rosalind Allen

Rosalind Allen is a professor of biological physics at Edinburgh University. She uses lab experiments and computational and theoretical models to understand how bacteria grow and interact in communities. Recently she is especially interested in how antibiotics work and how antibiotic resistance evolves. Before moving to Edinburgh in 2006, Rosalind did her PhD in theoretical chemistry at Cambridge University and did a postdoc in the Biochemical Networks group at the AMOLF institute in Amsterdam.

Susan Cox

Susan is a Royal Society University Research Fellow at King's College London, where she works on the analysis of single molecule localisation, as part of her strong interest in super-resolution imaging.

Mark Wallace

Mark's group builds artificial mimics of cell membranes, to both understand membrane biophysics and engineer new devices inspired by membrane biology. His group also develops a range of new single-molecule optical methods to help study these phenomena. Mark acts as the British Biophysical Society representative on the IoP Biological subgroup committee.

Mark studied Chemical Physics as an undergraduate at the University of Bristol, followed by a PhD in Chemistry at the University of Cambridge with David Klenerman. After postdocs at Stanford (Dick Zare) and the National Institute for Medical Research (Justin Molloy), he moved to Oxford in 2005 as a Royal Society URF. He was subsequently appointed as a University Lecturer and then Associate Professor in Chemistry. In 2016 he moved to help re-establish Chemistry at King's College London.

Chiu Fan Lee

I obtained a Joint Honours Degree in Mathematics and Physics from McGill University, with an Honours Thesis on Number Theory and Elliptic Curves. I then studied at Cambridge University for a Master of Advanced Study degree in Mathematics, specialising in quantum information theory and theoretical physics, and then at Oxford University for my DPhil. After my DPhil, I stayed in Oxford as a research fellow and gradually switched my research focus to biological physics. I then worked in the Biological Physics Division at the Max Planck Institute for the Physics of Complex Systems in Dresden before taking up my lectureship at Imperial College London in 2012. I now

investigate universal behaviour in biology. Specific systems of interest are protein amyloid self-assembly and pathogenesis, phase separation in the cell cytoplasm, and active matter.

Ewa Paluch

Ewa Paluch is a Group Leader at LMCB , and is both Professor of Cell Biophysics at UCL and chair of the Institute for the Physics of Living systems. Chair. She studied Physics and Mathematics at the École Normale Supérieure in Lyon, France. She did her PhD (2001-2005) at the Curie Institute in Paris, under the supervision of Cécile Sykes and Michel Bornens, investigating actin networks mechanics in vitro *and in cells. In 2006, directly after her PhD, she moved to Dresden to start her own Research Group at the Max Planck Institute of Molecular Cell Biology and Genetics, as a joint appointment with the International Institute of Molecular and Cell Biology in Warsaw. She was appointed Professor of Cell Biophysics and MRC programme leader at the MRC Laboratory for Molecular Cell Biology, University College London, in January 2013*

Michelle Peckham

Michelle trained in biology/physiology doing her UG degree at the University of York, and PhD at UCL. She worked on muscle birefringence with Malcolm Irving at KCL (Biophysics), fluorescence polarisation measurements (UCSF) and insect flight muscle mechanics (York) before becoming a Royal Society URF at KCL, Biophysics (Randall Institute), where she started her own lab. She moved to the University of Leeds in 1997, and is now a Professor of Cell Biology, and the current president of the Royal Microscopical Society. She is interested in the cytoskeleton, molecular motors, and muscle, and uses super-resolution imaging in her research.

Meeting Reports

Quantitative approaches to antimicrobial resistance

Jamie Hobbs and Rosalind Allen

Satellite meeting of the 19th IUPAB congress and 11th EBSA congress
Edinburgh International Conference Centre, 20th-21st July 2017

Antimicrobial resistance (AMR) is one of the most urgent emerging threats to global health. AMR has been estimated by the economist Jim O'Neill to have a potential cost of $100 trillion by 2050 if not addressed. Strategies to combat AMR include reducing the use of antibiotics in medicine and agriculture and increasing the pipeline of discovery of new antibiotics. Remarkably, many fundamental questions about how antibiotics work and how resistance emerges remain unanswered – we need to close this knowledge gap if we are to be able to rationally optimise antibiotic use. Quantitative science has a key role to play in this emerging field, just it has already come to have in many other fields of biology. This meeting, sponsored by IoP, EBSA and PolNet2, aimed to strengthen the emerging UK and international research community working on quantitative approaches to AMR, and to discuss the most important priorities and requirements for future research in this field. The meeting attracted around 50 participants with a healthy mixture of physical scientists and biologists. We were especially happy with the quantity and quality of the posters presented and the lively discussions that happened around them.

The interplay between antibiotic mechanism of action and the physiology of a bacterial cell formed one of the focuses of the meeting. For example, understanding quantitatively how translation works is a prerequisite for predicting how antibiotics that target bacterial ribosomes will act, and models for the physiology of individual ribosome targeting antibiotics (Scott) can, to some extent, predict what happens with combinations of such antibiotics (Kavcic). As another example, the physiology of cell size regulation also has intimate interplay with antibiotic action (Banerjee). Understanding the connection between bacterial physiology and antimicrobial action is important not just for conventional antibiotics but also for "natural" antimicrobials such as bacteriophage (Scott) and predatory bacteria (Sockett), both of which are promising alternatives to antibiotics for treating infections.

Going beyond antibiotic mechanism of action, it is also important to understand quantitatively how bacteria evolve resistance to antibiotics. An important link exists between the steepness of an antibiotic's dose-response curve and the distribution of fitness effects of potential resistance mutations; moreover some mutations can slow the evolution of resistance (Bollenbach). In real clinical scenarios, antibiotic dosage changes in time; pulsed doses of antibiotics can select for bacteria that show tolerance rather than resistance; this may be a stepping stone on the pathway to evolution of resistance (Balaban). The mechanism by which resistance evolves may also have an interplay with bacterial physiology via the formation of filamentous cells, containing multiple potentially mutated chromosomes; recombination between chromosomes in filamentous cells could accelerate the evolution of resistance (Austin). Finally, horizontal gene transfer (HGT) is believed to be crucial in the spread of antimicrobial resistance. HGT can be observed on a single cell level using optical tweezers, and the ability (or not) of a strain to perform HGT may (or may not) be correlated to its success in evolving antimicrobial resistance (Maier).

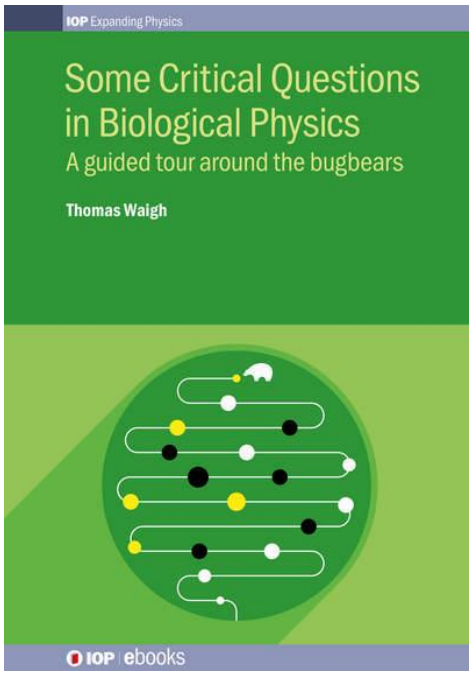
Detection of antimicrobial resistance is an important issue, from the molecular level to the level of infectious populations. On the molecular scale, new methods are being developed for visualising single molecules such as outer membrane pores, often implicated in AMR (Leake), for detecting changes in methylation of ribosomal RNA, also associated with AMR (Ranasinghe), and for imaging the detailed structure of bacterial peptidoglycan, which is crucial for understanding how cell wall-targeting antibiotics work (Turner).

To be relevant in the clinic, quantitative approaches to AMR need to reach towards clinical practice. Exciting developments in this direction include achieving a better understanding of the dynamics of infection and co-infection of immune cells by Staphylococcus aureus (Foster), mimicking in the lab the effects of co-treatment of cystic fibrosis biofilm infections with tobramycin and bicarbonate (Gordon), and using molecular donors of the signal molecule nitric oxide to disrupt lung biofilms – an approach that is now in phase 2 clinical trials (Webb).
On the second day of the workshop we had an interesting and useful discussion session, which highlighted several topics to focus on in future meetings. Communication and integration with clinicians emerged as an important theme, as did bridging between "physicists'" models and clinical reality. The opportunities and challenges posed by high throughput analysis, by the multi-scale nature of antibiotic action and resistance evolution, and by the need for in vivo imaging and fast diagnosis of bacterial infections, were also raised as important topics that could be covered in future workshops.

Report on *Quantitative Methods in Gene Regulation IV* **–**
Pietro Cicuta

The 4th edition of Quantitative Methods in Gene Regulation 2-day meeting, traditionally held biannually, was very successful (**18-19 December 2017, Corpus Christi, Cambridge**). 45 people attended an intense programme with 9 invited speakers (2 USA), 13 contributed speakers, short flash talks from all other contributors, and a general discussion on the state of the community and future directions. People attending represented a balanced mix of physicists and biologists, mostly UK but including many international. We recognised a core of participants who have attended many of the previous meetings, but also many people attending this for the first time. We are very grateful for the sponsorship from PoL2, IOP, RSB and CNRS, which was essential to allow affordable conference charges and especially to set very low student rates.
The meeting developed various scientific themes. One is the structure of chromosomes, which in different ways was the topic of both L.Mirny and N.Kleckner opening/closing lectures and other talks. The relation between chromosome structure, intended as its "polymeric" packing, with gene expression and other aspects of cell physiology, is clearly still an active area of both experimental and theoretical research. Many other talks also exemplified questions that call for joint forces from physical and life sciences, from antimicrobial resistance to quantitative analysis of energy production and metabolism in cells, from cell size regulation to epigenetics and the processes at play in development.
The open discussion forum was extremely active: we asked ourselves about examples of best practice and strategies to promote inter-disciplinary activities and structures in our various institutions and countries. Examples of barriers. Ways in which we could community build and create effective research teams. **T**he set of talks had highlighted how statistical mechanics (and other physical mechanistic models) can have significant impact on understanding key biological processes. The (well known) challenges of this interdisciplinary activity are in two directions. (1) the physicist wants/needs to know or understand a reduced or well-defined system; this needs to be worked out and respect the possible great complexity of the actual living system. (2) the impact and insight provided by proper physical-based mechanistic models is only really evident, and its deep value can be exploited further, by researchers who understand the underlying physics, which is not normally the case with life scientists. These are the reasons why the two communities need sustained dialogue. Sometimes people will become cross-educated, other times research units will remain mixed, composed of experts from both areas.

The meeting gave ample occasions of discussion and for people to meet. It is unclear how we can track down exact future outcomes. We know from this being a successful 4th edition, and from attendants asking for the series to be sustained, that this meeting has nucleated a lively community and serves as an important and unique reference point. We hope to run a 5th meeting in 2019.



A new book
'Some Critical Questions in Biological Physics: A guided tour around the bugbears' by Tom Waigh discusses eighteen key questions in biological physics, each forming independent chapters that will, by presenting the research in terms of key, unsolved problems, encourage interest in the field. It also provides useful reading for undergraduate physical scientists considering a career in this area.

Upcoming Meetings

Stochastic models of evolving populations: from bacteria to cancer
16-20 July 2018, Edinburgh
http://www.icms.org.uk/stochasticmodels.php

"Single-molecule bacteriology" Biochemical Society: Harden Conference (and see flyer below) 9-12 Sept 2018, Oxford.
Many UK biophysicists are in the program! Invited speakers include Taekjip Ha (Johns Hopkins), Johan Elf (Uppsala), Nynke Dekker (Delft), Antoine van Oijen (Woolongong), Johan Paulsson (Harvard), Suliana Manley (EPFL), Edward Lemke (EMBL), Julie Biteen (Michigan), Seamus Holden (Newcastle), Ricardo Henriques (UCL), Pietro Cicuta (Cambridge), Marcelo Nollman (Montpellier) and 13 additional UK and international speakers.

For more information, see:
bit.ly/84Harden
Registration and early deadline 9 July 2018

Physics of Living Matter meeting, 11-12 September 2018 Marseille
http://www.plm-symposium.org

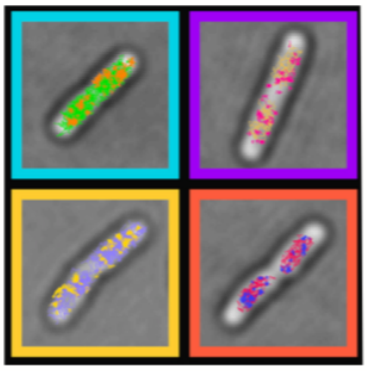
BIOCHEMICAL SOCIETY

Harden Conferences

84th Harden Conference: Single-molecule bacteriology

9–12 September 2018
Lady Margaret Hall, Oxford, UK

This interdisciplinary meeting will bring together scientists using cutting-edge single-molecule imaging to study mechanisms inside single cells, physicists and engineers driving rapid progress in methodology, and microbiologists applying advanced imaging to basic questions in bacteriology.



Topics will include:

- structural/mechanistic studies using super-resolution and single-molecule methods
- studies of genetic and membrane processes
- new quantitative *in vivo* techniques
- single-cell studies of biomedical significance

Organisers:

Achilles Kapanidis (Oxford)
Meriem El Karoui (Edinburgh)
Stephan Uphoff (Oxford)
Jie Xiao (Johns Hopkins)

Submit your abstract now

Abstract and Earlybird Deadline

9 July 2018

EPSRC Pioneering research and skills

UNDERSTANDING THE Physics of Life

BBSRC bioscience for the future

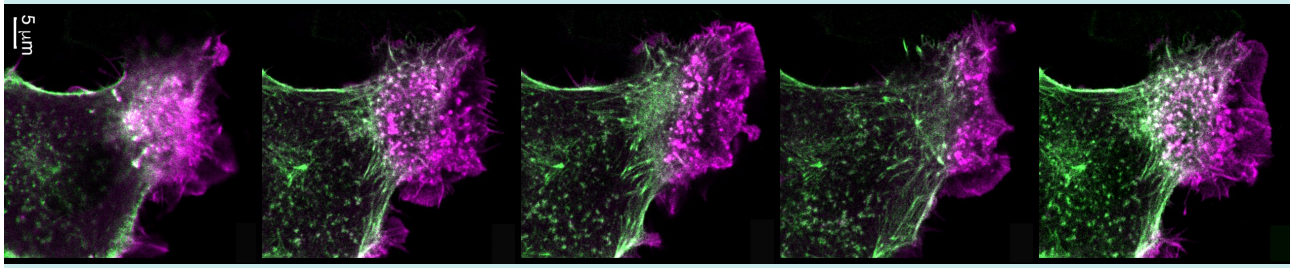


Image: RUFFLING CELL - A cell expressing a GFP Affimer for actin (green) and mcherry actin (magenta)
Image Credit: Michelle Peckham (Leeds)

Multi-scale mechanics in biology:

Current Challenges and Potential Solutions for Healthcare Applications

15-16 May, Weetwood Hall, Leeds

Overview:

Multiscale mechanics of biological systems has emerged as an exciting area of research and provides enormous opportunities for innovative multidisciplinary basic research and technological advancement. This workshop will discuss current experimental and theoretical tools for exploring the mechanical properties of biological soft matter, including proteins, polymers, membranes, fibrous networks, cells and tissues. The possibilities of understanding biological systems which span multiple scales, both spatial and temporal, and the challenges involved in bringing this knowledge together into a single multi scale understanding will also be explored. Finally, example success stories, where knowledge of physics at each length scale has resulted in novel approaches to solving clinical challenges will be given. We aim to bring together physical scientists, biologists, engineers and medical disciplines.

Organisers:

Lorna Dougan (Leeds), Steve Smye (NIHR/Leeds/Kings College London), Marlene Mengoni (Leeds), Michelle Peckham (Leeds), David Head (Leeds)

Speakers:

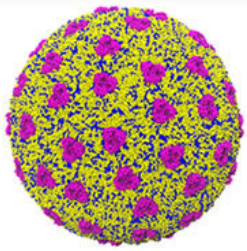
Laurent Blanchoin (Grenoble)
Gijsje Koenderink (AMOLF)
Cornelius Storm (Eindhoven)
Robert Ariens (Leeds)
Daniel Frankel (Newcastle)
Ewa Paluch (UCL/Cambridge)
Vasileios Vavourakis (UCL)
Ruth Wilcox (Leeds)

REGISTER HERE:
http://www.physicsoflife.org.uk/multiscale-mechanics-in-biology.html

REGISTRATION FEE: £40 *** Includes lunches, refreshments and conference dinner.**
REGISTRATION DEADLINE: 01 May 2018

BBS Biennial Meeting: Registration Is Open!

11-13 July 2018, University of Southampton



British Biophysical Society Biennial Meeting

11–13 July 2018, University of Southampton, UK

British Biophysical Society

The 2018 BBS biennial meeting is being held at the University of Southampton, on 11-13th July. The meeting will feature an exciting programme of scientific seminars and poster sessions across a wide range of biophysical areas and techniques: Cell Membranes, Cell interior, The whole cell, Delivery into the Cell and Emerging Imaging Technologies. The meeting is jointly sponsored by the Institute of Physics, biological physics group and will feature lectures from both the BBS and IOP medal winners for this year.
Young researchers are particularly encouraged to submit their abstracts, as approximately 50% of all talks will be selected from the submitted abstracts.

Organiser: Syma Khalid (S.Khalid@soton.ac.uk)

Plenary speaker:
Hartmut Michel (MPI, Frankfurt)
Keynote speakers:
Mark Sansom, (Oxford)
Martin Howard (John Innes)
Kristin Parent (Michigan)
Invited speakers:
David Roper (Warwick)
Sarah Harris (Leeds)
Ivo Tews (Southampton)
Mark Wallace (King's College London)
Tanmay Bharat (Oxford)
Kees Weijer (Dundee)
Sumeet Mahajan (Southampton)

Early registration deadline: 21 May 2018 Registration deadline:
21 June 2018 Abstract submission deadline:21 May 2018

Early bird rate: Full price (BBS member): £330, Full price (non-member): £360
Student rate: £250, Day rate (no accommodation included): £100

BBS Bursaries are available to help with travel, accommodation and registration costs for younger BBS members (undergraduate, postgraduate, or first three years postdoc) who are attending meetings associated with biophysics. For more information on bursaries, visit:
http://britishbiophysics.org.uk/student-bursaries

For more information and to register, visit:
https://www.iopconferences.org/iop/frontend/reg/thome.csp?pageID=746270&eventID=1231&traceRedir=2

IOP Institute of Physics

Physics of Cells: From Biochemical to Mechanical (PhysCell 2018)

3–7 September 2018, The Majestic Hotel, Harrogate, UK

An interdisciplinary conference on experimental measurements and theoretical modelling to further our understanding of cells, their inner workings and interactions with their surroundings. This conference will bring together the best scientific minds from different backgrounds to exchange ideas and discuss the latest results and future directions. We particularly encourage the emerging generation of bright young scientists to participate.

Topics:

- Biochemical and mechanical aspects of cells
- Different length scales – from molecules to tissues, subcellular to multicellular
- Interactions between cells and their environment

Organising committee:

Guillaume Charras, University College London
Rhoda Hawkins, University of Sheffield (Chair)
Nicolas Olivier, University of Sheffield
Ewa Paluch, University College London

Key dates:

Abstract submission deadline	**18 May 2018**
Early registration deadline	**6 July 2018**
Registration deadline	**31 August 2018**