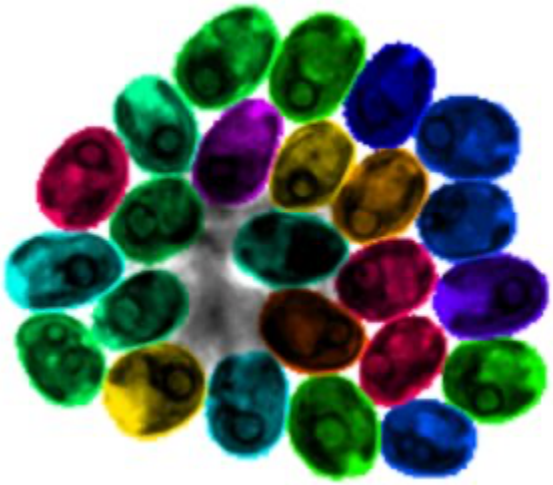
IOP Institute of Physics
Biological Physics Group

NEWSLETTER

September 2021

Issue no. 19



Cover Image from Pietro Cicuta:

Experiment by S.T.Chua and X.Li on Chlamydomonas immobilised in gels, growing in colonies. We are interested in colony morphology and in single cell properties such as growth rates and timing of division, and the effects of vitamin B12 on these.

Contents

Items for the newsletter should be e-mailed to
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The Chair's commentary

Dear Biological Physics Group,

I hope you are all well - it's my pleasure to write to you my final editorial as Chair of the committee. My three years "in charge" are over and you will soon be under the very capable leadership of Prof. Mark Leake. Mark is a thoughtful and deep thinker, expert in both biological physics and its UK community. You will not miss me! I, however, will miss the committee. I've been on it since 2010, first as an "ordinary" member and then as Treasurer. I have learned so much about our community and enjoyed every conversation we've had in this time. 2010 seems another epoch in both my professional career and perhaps in how UK biological physics has taken shape. Allow me a few thoughts of farewell! Very few Physics departments had cell culture facilities in 2010, and if there were biophysics courses they were focused tightly on the molecular scale. Much of the "bio" work that was carried out in Physics was in-vitro assays, be they centred on lipid membranes, cytoskeletal networks, or even purely on protein interactions. The IOP group had been set up just a few years before, its first Chair was Prof. Dame Athene Donald - she, like many others, had come to biological physics from previous experience in soft matter systems. 2010 was also the year that the "Physics of Medicine" building was inaugurated at the Cavendish Lab in Cambridge. That building, and similar facilities that have been set up across the country, dramatically changed the way we could address biological systems. Today, many of us capably handle living systems within our physics departments, or in genuine cross-disciplinary environments, making entirely new research possible, for example integrating new tools and designing experiments that are as systematic as many other areas of condensed matter physics. This allows us to think in terms of physics models and mechanisms. Increasingly as a community we are also looking beyond model organisms, and our biological questions are often original and distinct from the mainstream of life sciences, motivated by a physics intuition (e.g. collective motions of cells in tissues).

The new generations of students and post-docs entering our labs are the first to have been taught systematic biological physics courses, and increasingly some come and work with us without a physics background at all. They are perhaps weaker in the aspects of physics that we were fluent about in 2010. Today's generation might pick up advanced soft matter and statistical physics as accessories, as and when they are relevant to their work, in the same way that they might need to look deeper into optics, coding for image analysis or anything else. I have to constantly remind myself that they don't have the same background, or even language, that would have been common 10 years ago. On the other hand they (and perhaps we!) now know so many more other things! In 2010 I'm pretty sure that a biological physicist's average vocabulary and understanding around cells, tissues and development was nowhere close to where we are now. The "Physics Meets Biology" conference, which is our regular main meeting, has been running

for this whole time and those of you who have attended over the years will have seen this transformation to a much more mature community. It is a positive evolution in my view: our teaching and our knowledge are aligning to what we want to research. We should not, or course, take this to the extreme and dilute our expertise of "physics" in its various meanings, since that is our "USP".

On reflecting about this decade, I have a positive thought and a slightly more negative one. I think we have travelled in the right direction, and national programmes like the "Physics of Life Network" and related funding calls show that (finally) there are resources (at least some) that match our interests, and perhaps more importantly a recognition at the general science level that physicists can make important contributions to today's biology, often by working together with biologists and clinicians. This of course needs to be nurtured and consolidated, being aware that the more resources go this way the more scrutiny and expectation there will be that they are used better than by funding purely within the standard disciplines. But I am optimistic in all that, based on many successes. Where I think we have not done as well as we hoped is in carrying with us the traditional physics community. It's not that we have failed in the last 10 years: the IOP group has grown steadily in membership, and all major physics departments have researchers looking at living systems. Also, many biological physicists have always found good homes in other departments, from chemical engineering to mathematics, and directly embedding in even biology institutes. But my concern is that despite the excitement of our field, the new teaching courses we developed, the fundamental progress that it is possible to achieve even with relatively small teams, the relevance to real challenges that matter to the public.... despite all this, we are still seen as one of the various sectors of "applied physics". We have not impacted the "physics culture" very much: particle physics, astrophysics or cold atoms are not considered as physics applied to particles, stars or cold atoms... they somehow are still "the physics". Please email me to correct me if I am wrong, and I'd love to discuss this theme further - I don't see, for example, much evidence of Physics departments significantly addressing their teaching syllabus towards what might be the most useful bits of mathematics and basic physics for our area. This is unfortunate because a lot of what we "need" are topics in statistical physics, network science, dynamical systems beyond mechanical examples... and these are all topics that underpin modern technologies and trends that are changing our world. I won't even start on what might be useful experimental skills to teach students. This cultural aspect of where we sit within physics therefore matters quite a lot. It seems to me that we struggle against factors that are holding physics back in an unhelpful way. As a biological physics community, we have been very concerned about joining up well with life scientists. We should continue that, but I think we should also take a stronger position on what is the future of our own discipline.

Let me finish off this editorial with a consideration on the last year and a half, which we have lived within the pandemic. Obviously, this has had a tragic cost of lives in many countries, an economic cost, a cost in quality of life, and will continue to affect our lives for some time in the ways we have come to know, and perhaps in new ways too. Many of the lasting effects are undesirable, and we would want to change back most things to how they were in 2019 if we could. Much of the work of our committee concerns promoting meetings of all sorts, and we have remained very active throughout this period, trying out a variety of formats. Much has been said about the benefits of learning how to talk online in relatively large groups - we can save time, carbon footprint, potentially we make our meetings more accessible globally, and to people with childcare or other constraints. These are real important benefits. This "new way" has been wonderful for sharing knowledge in one-way communication (e.g. making great lectures available to anyone) and also for running business among people who already know each other. I'm not sure that we have cracked how to meet new people, which is so important for forming personal networks at early career, and how to make these events as enjoyable as our old in-person meetings... so hopefully the future will find a good balance.

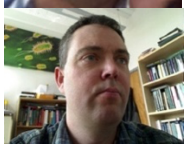
The pandemic is not over and will continue to provide challenges that many of us in the group will take on, willingly or otherwise. This year could well be rocky particularly in UK higher education, as our universities and the broader economy continue to adapt to the new relationship with the EU. I encourage you to engage with the new committee and to make sure we stay joined up in these quite uncharted waters.

best wishes, Pietro Cicuta

The current committee

Dr Pietro Cicuta (Chair),
University of Cambridge.
The Physics that underpins much of our thinking comes from soft matter physics (liquid interfaces and membranes), statistical mechanics, complex and dynamical systems

Professor Mark Leake (Secretary),
University of York
Develops new biophysical instrumentation to apply to open biological questions



Dr Thomas Waigh (Treasurer)
University of Manchester
Biophysicist who researches biomolecules, and cells, and is interested in biophotonics techniques

Dr Marco Mazza
University of Loughborough
Uses theory and computer simulations across scales to identify the driving mechanisms of complex matter organization

Dr Chiu Fan Lee (Website).
Imperial College London:
Works on universal behaviour in biology, protein amyloid self-assembly and pathogenesis, phase separation in the cell cytoplasm, and active matter

Professor Ewa Paluch
University of Cambridge
Interested in the mechanobiology of shape control.

Professor Mark Wallace
(*cross representative with BBS)*
KCL
Mark's group builds artificial mimics of cell membranes

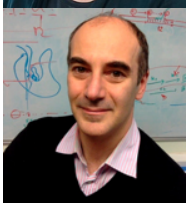
Dr Margarita Staykova,
University of Durham
Interested in understanding the functional principles of biological membranes and capture them in artificially designed smart interfaces

Dr Bartlomiej Waclaw,
University of Edinburgh,
Interested in applications of statistical and soft matter physics to biological evolution

Dr Andela Saric,
UCL,
Andela uses computer simulations to study biological assembly.

Dr Peter Petrov
University of Exeter
Biophysics of cell membranes in health and disease

Professor Michelle Peckham
(Newsletter),
University of Leeds.
Interested in the cytoskeleton, molecular motors, super-resolution imaging.



Professor Achillefs Kapanidis
University of Oxford
Develops single-molecule fluorescence microscopy. Research into microbial biological machinery in gene expression, maintenance, and regulation, with a focus on gene transcription and DNA repair

MOVIE COMPETITION Deadline 26th November

BP committee announce the 2021 Biological Physics short movie competition. The 2020 movies are available to see here:

https://sites.google.com/view/biologicalphysicsgroupuk/short-movie-competitions

The rules for this year are:
Deadline 26th November 2021 [important, note: there will be no extensions, as winners to be announced at the Early Career day on the 8th December]
Max 3 minutes (including titles).
Must be self-produced by early career (PhDs, postdocs, Fellows).
Permission of PI must be obtained.
Competition is open to members of the IOP Biological Physics group (at least one of the people credited must be a member). See http://www.iop.org/activity/groups/subject/bp/#gref for joining.
Video should be pitched to level of a physics undergraduate.
Prizes: £250 for Winner and £100 for a Jury's Award.
By submitting the video, you allow the IOP committee to make use of the material for the purpose of highlighting the community, for example a collection might be posted on youtube after the competition.

Movies should be compressed with a suitable codec so that they are <250MB in size. They should be in avi format and playable by vlc player on a windows OS. They should be put on some online repository and a link to them made available to Prof Pietro Cicuta, with an email to pc245 at cam.ac.uk by the deadline. The email should cc the PI and should contain a statement that the conditions above are understood and agreed to.

Upcoming meetings:

Early Career Day. 8th December 2021
BP committee announce an online Early Career day on the 8th December. This follows a successful day in 2020, and will feature one invited lecture, talks (with prizes) by early career researchers, and a career development session. Please see the IOP website for more details.

Meeting Reports:

Single Molecule Bacteriology: (Achilefs Kapanidis) July 2021
Achilefs ran on online event (with Biochemisty Society) in July with >100 registrations and ~60 attendees through the afternoon. We had some brilliant talks, essentially all from early career researchers, plus 2 keynotes (Antoine van Oijen, U of Wollongong, and Stephanie Weber, McGill). Lots of enthusiasm and interaction in the break out rooms! Looking forward to the 2022 meeting on Single-molecule bacteriology, hopefully in person!

Physics of Emergent Behaviour III – From origin of life to multicellularity: July 2021 (Chiu Fan Lee)
Our universe, together with its accompanying laws of physics, started about 14 billion years ago. Not long after the Earth formed around 4.5 billion years ago, life emerged and complexified, thus marking the beginning of biology. Biology and physics are now two distinct scientific disciplines, but by focusing at the earliest time point when biology emerges from physics, could we, with hindsight, have foretold the rise of life, or predicted key properties of biology, from the laws of physics? These will be some of the thought-provoking questions we will tackle at this online meeting: Physics of Emergence III: from Origin of Life to Multicellularity. Besides short talks delivered by our international speakers aimed at a broad audience, significant portion of the meeting will also be on open discussion. The meeting is supported by the Imperial

College Network of Excellence: Physics of Life, and the Biological Physics Group at the Institute of Physics (UK).

Physics meets Biology 2021, 26-28 July 2021.
(Report from Mark Leake)

What a genuine pleasure to see so many familiar faces at Physics meets Biology 2021 (PMB2021 – if only it could have been in 3 spatial dimensions and in-person, but even so this was a real treat!

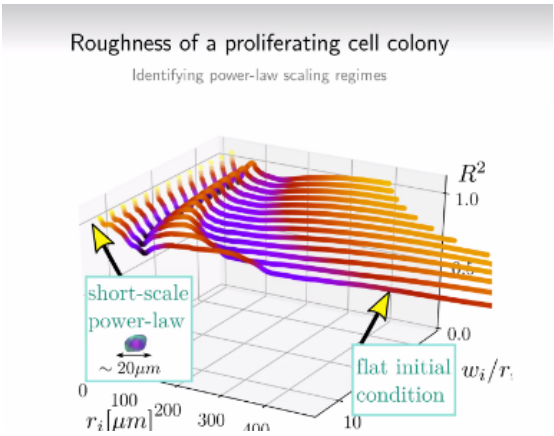
-Prof Mark Leake (University of York, UK)

Day 1

After a warm introduction from Andrew Turberfield (University of Oxford) as the chair of the organising committee, PMB 2021 kicked off with a great sessions chain by Michelle Peckham (University of Leeds) and starting with a talk from plenary speaker Iva Tolic (Ruđer Bošković Institute, Zagreb, Croatia) Zooming in from a tiny holiday island with excellent internet connection in the Adriatic, giving some fantastic insights about the forces involved in mitosis – why the spindle not understood well, due to multiple interactions often acting in redundant pathways. Using live fluorescence microscopy measurements of fluorescent protein reporters to molecular proteins and track enables calculation of speed of individual microtubules not reported previously, allowing the development of a new model to explain centring of the centrosome that involves bridging fibers travel faster than the kinetochore fibers.

This work linked well to the following invited talk of Emmanuel Derivery (MRC Laboratory of Molecular Medicine) who described insights off asymmetric cell division and how this partition components between mother and daughter cells, in particular the role of the Par complex, taking a synthetic biology approach to make 2D crystalline arrays between two Par proteins A and B, as a template to build up clusters of transmembrane complexes, visualised using both florescence microscopy and fast AFM.

Sessions 2, chaired by Rosana Collpardo (University of Cambridge) began with a wonderful talk from Rhoda Hawkins (University of Sheffield) about developing new models to explain liquid droplets moving in fluids of a lower viscosity, involving force dipoles and quadrupoles, capturing the effects of actomyosin contraction inside the cell that generate vortices. These models were then applied to modelling the deformation of the cell nucleus.



Nirvana Caballero (University of Geneva, Switzerland) then gave us a fascinating talk about how to model emergent behaviour of cell migration but analysing the morphology of interfaces of the cell population spread.

We then had a talk from Xiuyun Jiang (University College London, UK) describing membrane reshaping by the protein ESCRT-III, involving a new minimal coarse-grained model capturing relative stiffness properties of co-polymers.

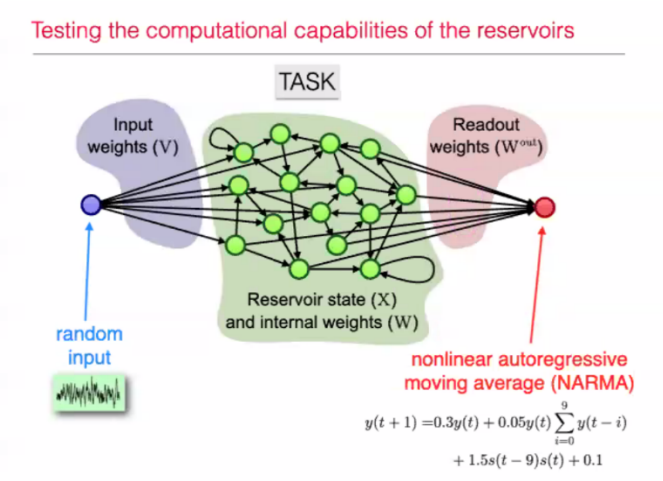
Session 3, chaired by Susan Cox (King's College London, UK) started with innovations from the invited speaker Rosana Collepardo, Cambridge University, UK on the **multiscale modelling of chromatin phase separation, followed up by a talk from** Mattia Marenda (University of Edinburgh, UK) on how **SAF-A nuclear protein regulates genome organisation by coupling super-resolution microscopy and polymer modelling of** artificial clusters. To end the session we had a talk from Allesia Lepore (University of Edinburgh, UK) to discuss the investigation of double-stranded DNA breaks in bacteria and the role of RecB proteins in repair DNA.

Session 5 chaired by Chiu Fan Lee (Imperial College London, UK), involved a valuable talk by keynote Cliff Brangwynne (Princeton University/HHMM, US) about the physics of intracellular phase transitions, and

drawing together consensus views from this topical field. Open discussions then continued in the virtual social networking session that followed.

Day 2

Laurence Wilson (University of York, UK) kicked off chairing Day 2, with keynote speaker Uri Alon (Weismann Institute, Israel), discussing new ideas relating to the mathematics of ageing, in particular the ubiquitous relationship across many species of the risk of death increasing exponentially with age, and why there are some important deviations from this such as slow growing, large organisms. Uri decided to take impromptu questions half way through leading to ~10 questions, and then had about 10 more at the end, absolutely brilliant engagement! We then began Session 2 with a short talk from Florian Oltsch (Max Planck Institute for molecular Cell Biology and Genetics Dresden, Germany), who highlighted **the importance of different sources of noise in cells in liquid -liquid phase separation, and how modelling these droplets can explain a lowering of protein concentration fluctuations. Invited speaker** Jordi Garcia Ojalvo (Universitat Pompeu Fabra, Spain) then described his modelling work on how cells process information through recurrent biological networks using machine learning approaches. We then finished the session with a short talk from Govind Menon (John Innes Centre, UK) who described the use of mathematical modelling to explain **epigenetic switching mediated by a co-transcriptional repression pathway at the model plant gene FLC.**



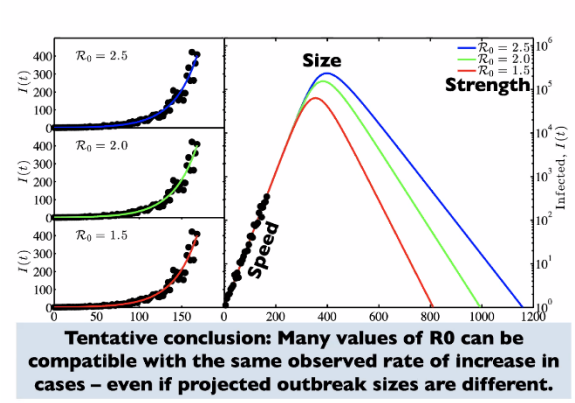
Andela Saric (University College London, UK) chaired Session 3, which began with a short talk from Ricard Alert (Princeton University, USA) **who described modelling topological defects to fruiting bodies in bacterial colonies from light microscopy images. We then had a talk from** Iago Grobas (University of Oxford, UK) who described modelling of swarming bacteria through multiple cell layers **from swarm cell data in which cells had been challenged with antibiotics. We then finished the session with a fascinating invited talk from Seamus Holden (Newcastle University, UK) about understanding biophysical principles of bacterial cell division using advanced light microscopy.**

Session 4 was chaired by Seamus Holden (Newcastle University, UK), which started with a talk from Laurence Wilson (University of York, UK) discussing the motility of halophilic archaea using high=speed digital holographic microscopy. Adedeji Olulana Abimbola Feyisara (University of Sheffield, UK) then gave a talk focused on using high-speed AFM to investigate the cell wall of antibiotic-resistant bacteria.

The session was concluded with an invited talk from Susan Cox (King's College London, UK) who discussed how to enhance high density super-resolution fluorescence microscopy data using Bayesian inference and deep learning.

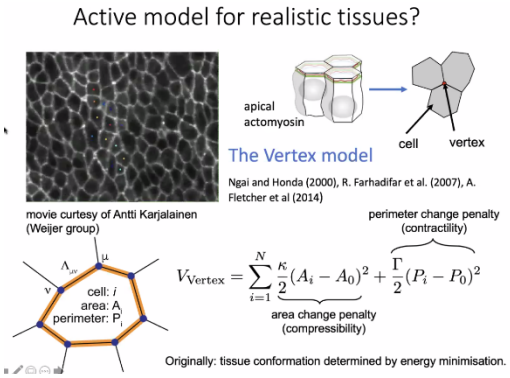
Session 5 was chaired by Mark Leake (University of York), beginning with a short talk concerning the application of small-angle scattering from X-ray coupled to time-resolved cryoEM to infer details about structural intermediates of the Hepatitis B virus capsid. We then had a talk from Charley Schaefer (University of York, UK) describing his modeling polymer physics modeling lead to insights of the molecular conformational transitions in spider silk. The session concluded with an engaging talk from invited speaker Yanlan Mao (University College London) about modeling the mechanical effects of tissue dynamics in developing and damaged fruit fly wings, leading to some excellent discussion.

Day 3



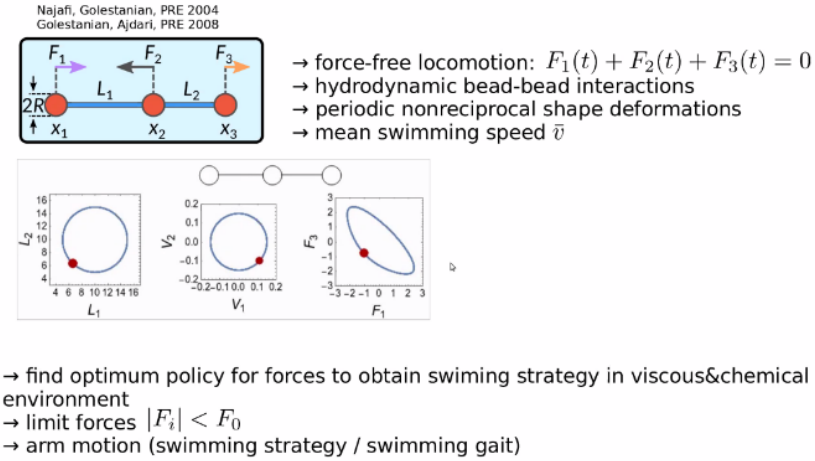
The third day started with chairing by Rhoda Hawkins (University of Sheffield) with a keynote talk from Joshua Weitz (Georgia Tech, USA) who gave a talk on lessons of modelling regarding pandemic theory and Pasteur's Quadrant using COVID-19 as the exemplar, in particular how the infection predictions are very sensitively dependent on not just immunity and vaccination levels, but on our understanding of human behaviour, and how this can help steer new intervention strategies when new epidemics arise. Session 2 then started with a talk from Laura Wadkin (Newcastle University, UK) on modelling the spread of tree diseases in the UK. We then had a talk from Philip Pearce (Harvard Medical School, US) who discussed modelling of bacterial quorum sensing. The session then ended a talk from invited speaker Silke Henkes (Bristol University) describing the collective cell mechanics in tissue development. Session3, chaired by Silke Henkes (Bristol University), started with invited speaker (Aleksandra Walczak, École Normale Supérieure, France) who described modelling of living imaging data relating to decision making in early fly development.

We then had a talk from Andreas Zöttl (TUWien, Austria) who described modelling the decision making of microswimmers in chemotaxis, using genetic algorithms.



We then closed the session with invited speaker Edouard Hannezo (IST Austria) talking about mechano-chemical patterning and optimal migration in cell monolayers.

The final keynote, chaired by Pietro Cicuta (University of Cambridge), was given by Rosalind Allen (University of Edinburgh) as the Tom Duke Prize Lecturer, describing Physics models for how antibiotics kill bacteria, focusing on the "fatness threshold" for bacterial cell division.



The meeting was closed by Andrew Turberfield, with special thanks to Rebecca MacLaurin from the IoP conference team, congratulations to the seven poster prize winners of Jan Cammann, Ludwig A. Hoffman, Molly Gravett, Aondoyima Ioratim-Uba, Rebecca Langdon, Emma Brock and Sarah Lecinski, and a big invitation to meet again in two years in Harrogate in the UK, in which this Physics meets Biology Biological Physics Group IoP meeting will join with by several other learned societies and organisations including the British Biophysical Society, the Physics of Living Systems, and the Physics of Life Network to produce what is hoped will be a truly comprehensive gathering of exceptional researchers at the physical-life sciences interface!