Division of Biological Physics
DBIO

And the award goes to...

There is a new APS DBIO Dissertation Award winner, a new APS DBIO Early Career Award winner, a new APS DBIO Max Delbruck Prize Award winner, and APS DBIO can lay claim to four new APS Fel-lows! More inside.

APS DBIO NEWSLETTER

December 2022

EDITOR: SARAH MARZEN

APS DBIO Membership trends show resilience in the face of COVID

While APS DBIO membership showed a dip in membership during the pandemic, it has recovered fully in 2022 and is boasting the highest female membership percentage from amongst the APS Divisions (25.9%, with second place to Astrophysics, with 24.5%).

To Jianhua Xing and Chair of the Member-ship Committee, the reason is clear: there is less need to be a member when the March Meeting is not in-person.

"We are resilient– we recovered from COVID, the whole community has started to recover," he said. "Hopefully it [the mem-bership] will go steadily up."

He is also happy but "not quite surprised" about the high percentage of females. "I think I'm happy our community is doing well at this and that the whole community is very supportive of diversity is very good."

He is looking towards the future as he talks, though, pointing out that "we need to attract young trainees because those are the future of our community." The percentage of students in APS DBIO is in the middle ground for APS Divisions, at 45.6%. "I think the community definitely has a very exciting future because the field decadal survey recognized our field and helped many departments recognize the importance and they will hopefully start to create training programs."

APS March Meeting is Hybrid in 2023

The American Physical Society's March Meeting brings together scientists and students from around the world to connect and collaborate across academia, industry, and major labs. Students, early-career physicists, and experienced profession-als will benefit from the networking and learning at March Meeting. Whether you join in-person or virtually, March Meet-ing 2023 is the perfect opportunity to share your research, network with other physicists, and learn about current issues relevant to the physics community.

Communicating Biological Physics: Tips and Tricks

On September 28, three scientific communicators convened in a panel moderated by APS DBIO ExComm Community Engagement Chair Nancy Forde to give tips and tricks for explaining science effectively: Janet Iwasa, an Assistant Professor of Biochemistry at the University of Utah and animation expert; Raghu Parthasarathy, the Alec and Kay Keith Professor of Physics at the University of Oregon and the writer of a recent book called "So Simple a Beginning"; and Philip Ball, a self-described freelancer who helps with everything from BBC radio to Nature News and Views.

A common thread? Biophysics is a hard sell. But the three panelists had different ways of dealing with this issue.

Iwasa even as a graduate student was "interested in synthesizing data into a visual hypothesis" and believes that detailed animations of cellular processes "not only helps our fellow scientist but can help our relationship with the public". As she describes it, starting with a typical textbook illustration with sticks and circles and adding the jargon of protein names can cause the audience's eyes to glaze over, no matter how important that process may be. But, she says, "if you show an animation that shows what is playing inside the scientist's head", the audience will understand why someone might study that process for their entire life and "can ask really good questions if you just make the science approachable and intuitive".

Parthasarathy emphasized that what biophysicists and biophysics students find compelling— how physics helps us appreciate the beauty of life— may not be what the layperson finds compelling. "Making connections to health and disease gets them, and biophysics could do more of this," he said. As an example, Parthasarathy does a highschool outreach activity in which he describes a physics-based treatment for infant respiratory distress syndrome, in which the lung is not able to breath due to a lack of lung surfactants. The medicine? Soap. And this isn't the exception to the rule. "High throughput DNA or RNA sequencing wouldn't have been possible without thinking physically about the constituents of life," said Parthasarathy.

And according to Ball, biophysics is a hard sell because "it demands a deep dive into molecules with complicated names and it's not clear what implications they have for what the public cares about… it's also a hard subject to sell because it lies outside the prevailing paradigm of life sciences today." He emphasized that all the public gets to see is that there is a complicated mapping from genes to behavior, and so it looks like there's not a lot of room in here for biophysics— but, said Ball, "My view is that there's a lot of physics at the core for what's going on in this black box," pointing to liquid-liquid condensates as an example.

And for those who are trying to communicate their science but feel as though no one is reading, Parthasarathy said, "Don't really worry if anyone will read it or not because that's very hard to control…. It's been a steady accumulation [of visitors on his blog] so don't be discouraged if you start out and feel as though you are talking to a void."

For more information, visit APS DBIO Engage and go to the Workshops and Networking page. The Zoom recording is available there!

Advice, straight from Phillip Ball

The classic error in communicating is to overestimate what the reader knows and underestimate the readers' intelligence.

1. Find the right story: what will work for a writer may not just be a simplified version of what you tell in the paper. The challenge for people like us is to find a hook that is meaningful to a wide audience without overhyping it.

2. Don't be afraid to include the human aspects. "There's nothing a reporter loves more than a good quote," said Ball. He remembered that once for BBC radio, "a young researcher harnessed biomolecular motors for nanotechnology but the interview was just kind of flat" and then, he said, "it occurred to me to ask him how he felt when he came into the lab that morning and everything lifted."

3. You probably don't need that jargon.

4. Find good metaphors. Ball said, "They are actually how all thinking works. If the one you're trying to use is becoming too baroque or too oblique, think again."

5. Know who you're pitching to. "Find the right editor to speak to…. Remember that most readers and most reporters know next to nothing about what you're describing," said Ball.

Incorporating Biological Physics into the Undergraduate Curriculum

Throughout the curriculum

Jane Kondev, Brandeis University

My real hope is that we can blow up the curriculum, but... that's for a different conversation. Efforts we've made here at Brandeis include at the first year level, put some numbers into biology and incorporate biology into physics. The scheme is to follow the usual progression of ideas in physics and try to at every stage of the game bring up modern cellular and molecular biology, which is a reflection of my own interests. To get a sense of this through vignette: there's an example of a biology and physics concept for every unit in course. For instsance, we use the bacterial life cycle to talk about energy (bacteriophage— internal force varies with length, get spring constant). There is no textbook, but we use Cell Biology by the Numbers. Students pick vignettes and present them in the classroom.

Special courses

Ashley Carter, Amherst

We now have a biophysics major that dwarfs physics and astronomy populations. The goals now are not graduate school preparation, but to create an interdisciplinary physics major. We updated statistical mechanics and advanced lab, the latter just by adding another experiment on biophysics, except you have to train everybody in your department on how to use that experiment! Updating statistical mechanics was interesting because the physicists have little thermodynamics knowledge while biophysicists know a ton of stuff about entropy and energy but don't have differential equations. To get everyone on the same page, we put in four weeks of introductory thermodynamics, and then we switch to a statistical mechanics book (Dill and Bromberg) that has a lot of biophysical examples.

New major

Patricia Soto, Creighton

This is a health sciences institution. One of the reasons why the physics department was created was to support the training of the pre-medical and medical students. All my physics colleagues think that if we develop our programs in biological physics and medical physics we will increase retention of students. We see a bit of a barrier in that our students in college are exposed to physics only after they have general biology and general chemistry. We developed an undergraduate major in biomedical physics and a Masters that has been growing in medical physics and Masters in physics.
How we can make it happen? Building connections with all colleagues who are not physicists.

For more information, check out the APS DBIO Engage.

Meet the winner of the APS DBIO Dissertation Award!

Jonathan Yuly, Princeton University

RESEARCH THAT NETTED YOU THE AWARD

The research surrounded the theory of electron bifurcating enzymes. Electron bifurcation is an energy transduction process, found in the last decade to be widespread across the tree of life, that oxidizes a two-electron donor species, using the electrons to reduce two separate one-electron acceptors. These electron transfers are coupled, so that the thermodynamically downhill flow of one electron is harnessed to push the other electron uphill. For decades, it was unknown how these enzymes catalyzed electron bifurcation, because productive electron transfers must compete with "short circuit" processes that result in all electrons flowing downhill. My research proposed a general mechanism based on established electron transfer theory to explain how efficient and reversible electron bifurcation could be accomplished.

My advisor was David Beratan, an accomplished electron transfer theorist who was a tremendous supporter in developing this research. He provided key insights along the way, especially in how to present the ideas in a simple and compelling way. Peng Zhang is a research faculty in the Beratan group, and we often worked closely together in developing models and testing simulations. This project also consulted intensely with our experimental collaborators, especially Carolyn Lubner (NREL), John Peters (WSU), and Gerrit Schut (UGA).

WHAT GOT YOU INTERESTED IN BIOPHYSICS?

I have always had wide ranging interests, but I finally decided that biophysics was my home in graduate school. It was almost by accident that I ended up in biophysics. Much of the work in the Beratan group focuses on the quantum mechanics of charge and energy transfer in molecules, research with clear applications in biology but from a very "zoomed in" perspective! My background was physics, so the familiar sight of quantum mechanics made me feel brave enough in the group to dip my toes into biophysics. But when I was introduced to biophysics through David, and through the papers and textbooks by Hopfield, Bialek, Phillips, Dill, and Hill, I fell in love with the subject! Living systems are a fantastic playground to play with physics ideas, and are a tremendous gift to physics.

WHAT DO YOU HOPE TO DO NEXT?

I just arrived at Princeton as an independent postdoc, officially within the Lewis-Sigler Institute for Integrative Genomics. I aim to explore biological systems at a larger scale, and learn about how "more is different" in biology. I haven't found "the problem" yet, but I am currently exploring unstable reaction diffusion on membranes, cellular regulation, and applications of statistical mechanics in biology. Maximum entropy/caliber continues to give!

WHAT'S YOUR FAVORITE SCIENCE PAPER AND WHY?

This question feels similar to asking "what is your favorite grain of sand at the beach?" Sure, grains of sand are cool but that's not why I go to the beach! Similarly, papers that seem boring at first are endowed with tremendous meaning when their context is understood, and although other papers often define the context, the context is way more interesting than the papers themselves. "More is different" when it comes to science papers.

One particular paper that influenced me to pursue biophysics further, however, was "Statistical mechanics for natural flocks of birds" by Bill Bialek and coworkers. It is a striking and thought provoking paper that (for me) spoke profoundly about both living systems and the nature of statistical mechanics.

Meet the winner of the APS DBIO Early Career Award!

Sujit Datta, Princeton University

RESEARCH THAT NETTED YOU THE AWARD

While typical lab assays of bacteria focus on cells in liquid cultures or at flat surfaces, many natural bacterial habitats—such as tissues and gels in our bodies, or soils and sediments in the ground beneath our feet—are more complex 3D spaces. For example, they can be crowded and structurally disordered, chemically heterogeneous, and have non-trivial rheological properties. How does inhabiting such complex environments change how bacteria behave? To address this question, my group has developed the ability to experimentally define and interrogate bacterial populations, from the scale of a single cell to that of an entire multicellular population, in controllably-complex 3D media. Using this platform, we have shown how confinement in a crowded space fundamentally alters how bacteria spread by motility or growth, both at the single cell and population scales, in previously unknown ways. Guided by these findings, we have developed theoretical models to more accurately predict the spreading of bacteria, and other forms "active" matter in general, in complex environments. Altogether, this work is shedding new light on the fascinating physics underlying microbiological processes in complex environments. It also may help to provide quantitative guidelines for the control of these processes in practice, such as in bioremediation, agriculture, biotechnology, and medicine.

Beyond research, I am also committed to contributing to the biophysics community through outreach and service. For example, I actively lead efforts to bring together diverse perspectives and provide access to researchers from traditionally under-represented and marginalized groups in this field. This includes through organizing multiple local and international workshops and symposia, such as the annual Soft Matter For All virtual symposium focused on promoting and celebrating the incredible diversity and creativity of early-career researchers studying soft and living matter. In addition, I consistently chair and organize DBIO sessions on active and living matter at the APS March Meeting, as well as serve as a reviewer for many of the key journals in our field, such as Physical Review journals, Biophysical Journal, and eLife.

WHAT GOT YOU INTERESTED IN BIOPHYS-

I wasn't specifically interested in science as a teen. My interests gravitated more to the humanities and especially to philosophy as a means of making sense of the fundamental nature of our world. But digging into the history of philosophy directly led me to the world of natural philosophy and ultimately to science.

The earliest philosophers asked incredibly profound scientific questions that captured my attention—and that we scientists still grapple with every single day. I was intrigued by the apparently conflicting world views of Heraclitus (who espoused that everything flows, anticipating what is now the established scientific field of rheology) and Democritus; similar questions were being posed by many other philosophers elsewhere, as well. I was struck by the creativity of Kepler, who tried to rationalize the different orbits of the different planets as being a series of inscribed Platonic solids. I remember being morbidly fascinated by Newton's gruesome sketches describing how he stuck a knitting needle into the fluid-filled space behind his eyeball to test whether the colors we see originate from within the eye or from the outside world. Questions like these eventually got me interested in mathematics and physics as a way of formally describing the world around us.

As an undergraduate, I was lucky to get a chance to join a lab, in which I worked on various problems in quantum nanoscience. The experience changed my life: I fell completely in love with research and the process of discovery. Phil Nelson had just published his gorgeous textbook on Biological Physics, which was my first introduction to the field. And then I joined the lab of Dave Weitz as a graduate student at Harvard. The Weitz lab was an incredible place for anyone interested in soft matter and biophysics, with ~60-80 people total (!) working on a vast array of topics. I was like a kid in an intellectual candy store. While my PhD research focused on non-biological problems in fluid and solid mechanics, my interest in biophysics kept growing as I kept being exposed to interesting problems in the field. It astounded me how, in many cases, tools and ideas from physics can actually meaningfully describe the messy and complex world of living systems. So when I was starting to think about graduating, I knew I wanted

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to continue doing research as a postdoc somewhere, but I knew I wanted to learn something about biology. And I wanted to step out of my comfort zone and fully immerse myself in that world.

At the time, the gut microbiome was getting a lot of attention – you hear about good bacteria and bad bacteria in the gut, and there's a lot of top-notch microbiology elucidating how they work. But of course, the gut is a very complex, dynamic, spatially-structured, "squishy" environment. So, I thought that ideas from soft matter and biophysics could be useful in understanding processes in the gut. My postdoc advisor, Rustem Ismagilov at Caltech, had just started up a new initiative on the gut microbiome, and I was lucky that he gave me the opportunity to join it, even though I knew absolutely nothing about the subject. And so I went from doing microfluidics experiments to doing surgeries on mice to study their guts. The world of biology was messy and complicated and completely new to me, and I loved it.

I spent my time bugging the biologists with seemingly simple questions that I realized people didn't yet have good answers to. For example, I was studying how bacteria interact with the porous mucus network that acts as a protective barrier lining the colon. So a simple question naturally arises: How long does it take a motile bacterium to swim through the pores of this network and traverse it? I couldn't find a good answer; most of current understanding of bacterial motility is based on studies of cells in bulk and unconfined liquids, not in more complex porous media. And so, addressing this question was one of the first goals I set for myself when I started my lab at Princeton. It's been a lot of fun. The unreasonable effectiveness of physics in helping to answer biological questions constantly amazes me.

WHAT DO YOU HOPE TO DO NEXT?

Our multi-scale visualization and continuum modeling have helped us uncover new biophysical principles describing the spreading, growth, and spatial organization of bacterial populations in complex 3D environments. But I believe we've only just scratched the surface. We are now exploring the generality of these principles by experimentally testing broader ranges of environmental structures and chemistries, as well as different species with varying shapes, motility kinematics, and growth behaviors.

Long-term, I am also excited to take this work in two new directions. First, while our work thus far focused on single-species populations, in nature, bacteria often self-organize into multi-species communities. How do the nature of inter-species and environmental interactions impact the spatial organization, growth, and stability of such communities? How does the spatial organization of a bacterial community impact its functioning in turn? I'm excited about the opportunities brought about by our experimental and theoretical advances to address these questions.

Second, these biophysical insights could help us design bacterial communities capable of functioning when they otherwise could not have—e.g., communities that can remove multiple contaminants from dirty water and could then be applied in practice to provide clean water in resource-limited settings. I'm excited about the potential of such studies to open new avenues of research by enabling the design of synthetic, environmentally-isolated, or hybrid synthetic-natural bacterial communities that are optimized for a given function.

WHAT'S YOUR FAVORITE SCIENCE PAPER AND WHY?

Again, this is an impossible question to answer: it's hard to pick just one favorite! There are way too many amazing papers that have educated and inspired me in multiple ways.

However, since I discussed our work on chemotaxis, I'll mention one of my favorite papers on the subject: "Physics of chemoreception" by Berg and Purcell, published in Biophysical J. In 1977. It's a remarkable paper. They considered a seemingly simple question: how does a micrometer-sized bacterial cell "measure" small changes in the concentration of surrounding chemicals as it moves—which is essential for chemotaxis? Using elegantly simple physical calculations and intuition, Berg and Purcell showed that this process is limited directly by molecule counting noise. And remarkably, they provided evidence that many bacteria operate in a manner that minimizes the effects of this noise, "[approaching] that of the cell of optimum design". The paper was ahead of its time. Indeed, in a beautiful paper 25 years later, Bill Bialek and Sima Setayeshgar revisited and generalized the Berg and Purcell arguments, showing that many bacteria do indeed operate near the limit set by diffusive counting noise. This provides just another example of the unreasonable effectiveness of physics in describing how remarkable living systems are.

HOW ABOUT ONE OF YOURS?

It is a little awkward for me to pick a favorite paper of my own. However, one recent paper that immediately comes to mind—because it was so fun to work on—is "Chemotactic smoothing of collective migration", which my group recently published in eLife (https://doi.org/10.7554/eLife.71226). This project was fun because it started with a surprising experimental observation that we were able to explain by integrating our experiments with theory and simulation, which was satisfying. And in doing so, we uncovered what we think is a potentially general mechanism that many active and living systems might use to stick together in groups.

Meet the new APS Fellows!

Thomas Gregor, Princeton University

CONTRIBUTION TO BIOPHYSICS COMMUNITY

Two things really: the first is that biological processes in the early fly embryo run at such high precision that it looks like the system is optimized, i.e. it runs as good as it could possibly do or need to do. And the second is that if you keep refining your experimental capabilities, you can even in as complex (i.e. out of equilibrium) a system as a developing fly embryo make physics-style measurements. And these in our case have led to unanticipated insights, such as the discovery of surprising regularities underlying the transcription processes of developmental genes that might lead to general (universal?) rules governing transcription processes in general.

My favorite paper of mine is looking at pattern reproducibility of veins on fly wings. They are reproducible from one individual to the next at the level of a single cell diameter, again the best one could hope for. And that reproducibility is as good as the symmetry between the left and the right wing of the same individual. It means that symmetry could in principle in this system be generated just by two independently running high-fidelity processes on the left and the right side of the animal; no special molecular processes needed that make sure the fly doesn't run against the next tree because of asymmetric wings.

WHAT GOT YOU INTERESTED IN BIOPHYSICS?

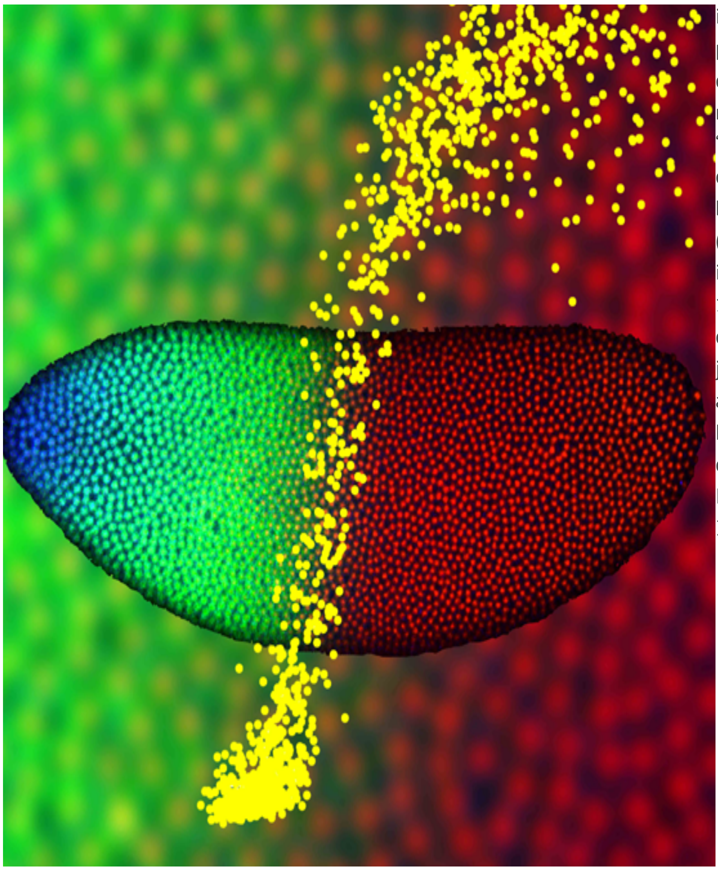
I always liked biology, and when I was done with my physics degree and realized that all this rigorous thinking and approach of the physical sciences could now be applied to living systems it was very easy for me to jump on the train of people who had realized this well before me. I never regretted, as finding the physics underpinnings of life is fascinating and a problem that will occupy us for decades to come.

WHAT DO YOU HOPE TO DO NEXT?

I have recently started to work with mammalian organoids, pseudo-embryos that self-organize from a bunch of embryonic stem-cells in a dish. We're trying to address similar kinds of questions than the ones we have looked at in the fly embryo, and if the answers are similar, well that means that the physical rules or principles that we thought organize a developing embryo might be properties of multicellular systems more generally, and that would be really exciting! And we have initial hints that that is indeed the case…

WHAT'S YOUR FAVORITE SCIENCE PAPER AND WHY?

There are two linked ones that are influencing and perturbing my day-to-day life more and more… "Energy and climate change" by JM Jancovici (Journal of Physics IV 121 (2004) 171-184 https://doi.org/10.1051/jp4:2004121011) and "Numbers Don't Lie" by Vaclav Smil (2019, ISBN 978-0-14-313622-4)



The image shows a Drosophila embryo 2 hr after fertilization, with nuclei at the surface fluorescently labeled for Bicoid protein (blue), Hunchback protein (green), and DNA (red). --Image from Thomas Gregor

Meet the new APS Fellows!

Olga Dudko, University of California, San Diego

CONTRIBUTION TO BIOPHYSICS COMMUNITY

My research strives to find compelling and unifying mathematical descriptions of the strikingly diverse processes in the living world, similarly to how unifying physical principles have been found to apply to disparate contexts of non-living matter. I enjoy developing analytically tractable (as opposed to purely numerical) theories that have a sufficient level of abstraction to be broadly applicable and at the same time generate concrete, testable predictions. With this approach, I have worked on solitons in magnetic nanostructures, the origin of friction at the nanoscale, diffusion in complex geometries, the response of single biomolecule to force, mechanisms of gene dosage compensation, virus-host cell interactions, the spatiotemporal organization of chromosomes in the cell, neuronal communication. Some of these theoretical frameworks provided a quantitative basis for breakthrough experiments. It has been especially rewarding to be able to share these intellectual adventures with bright and enthusiastic students.

I have recently been a member of the committee engaged in the first study of biological physics as part of the decadal survey of physics undertaken by the National Academies of Science, Engineering, and Medicine. Among the goals of such surveys is to get a sense for where the field is today and where it is going, and to influence the view of the field by all interested parties, from the funding agencies and congressional staff to university administrations and students.

As an editor at Physical Review Letters, I have the privilege of being among the first to see some of the most exciting research in the field, and to influence the field by showcasing some of the most important work. As an editor at Reviews of Modern Physics, my goal is to publish reviews in biological physics that not only are impactful right now but are also likely to achieve the legendary status, as has been the case with many reviews published by this journal throughout its history.

RELATEDLY, WHAT PAPER OF YOUR OWN IS YOUR FAVORITE AND WHY?

I won't be original here — my favorite paper of my own is always the one I am working on at the moment.

WHAT GOT YOU INTERESTED IN BIOPHYSICS?

The realization that one can be interested in biological problems and still be a theoretical physicist.

WHAT DO YOU HOPE TO DO NEXT?

I look forward to continue contributing to creating a powerful theoretical physics of living systems — one that reaches the levels of generality, mathematical rigor, and predictive power that are standard in more established subfields of physics.

WHAT'S YOUR FAVORITE SCIENCE PAPER

The answer to this question is time-dependent. I remember being enthralled as a kid by Yakov Perelman's "Physics for Entertainment", which I discovered in my physicists-parents home library. As a graduate student, I came across a short paper by Lev Landau "The theory of phase transitions", published in Nature in 1936. It was a simple and deep idea that gave good insights into something that seemed complicated and almost unapproachable. It is a hard standard, but I find it inspirational, especially when faced with the complexity of biology. It makes it even more special for me that Landau wrote this paper while working at the Ukrainian Physical-Technical Institute in my home city, Kharkiv.

Meet the new APS Fellows!

Roya Zandi, University of California, Riverside

CONTRIBUTION TO BIOPHYSICS COMMUNITY

The simplest viruses are made of a protein shell called the capsid and a genome molecule (RNA or DNA). Over the years, I have been applying the methods of statistical mechanics and condensed matter physics to understand factors contributing to the formation and stability of virus particles. Among many other questions, our research has shed light on, for example, why under quite different in vivo and in vitro conditions, virus coat proteins assemble to form error-free shells with icosahedral symmetry; why large icosahedral viruses need scaffolding proteins; and how virus coat proteins assemble around their native genome in the crowded environment of cells.

RELATEDLY, WHAT PAPER OF YOUR OWN IS YOUR FAVORITE AND WHY?

I have also studied the role of the electrostatic interaction, the topology of RNA and the protein and genome concentrations in the assembly pathways of virus particles.

One of my favorite papers is Siyu Li, Polly Roy, Alex Travesset, and Roya Zandi, "Why large icosahedral viruses need scaffolding proteins". Despite a plethora of experimental data provided by structural biologists, no theoretical/numerical explanations have been put forward to elucidate the indisputable need of large shells for scaffolding proteins. In this paper, we elucidated the "universal" role of template in conferring curvature for the formation of large spherical crystals and were able to explain the unexpected results of the numerical simulations regarding the kinetics of assembly of a large spherical shell into a symmetric structure. While elasticity theory has been continuously used to explain the structure of protein nanocages, the "exact" equations of elasticity theory are extremely challenging to solve. We solved for the first time the elasticity equations for a spherical cap with a moving boundary condition and showed that there is a deep attractive potential at the location of pentameric defects as the shell grows, explaining how hundreds of protein subunits assemble to form a symmetric structure.

WHAT GOT YOU INTERESTED IN BIOPHYSICS?

When I started going to graduate school back in 1995, I was planning to study condensed matter physics. I always wanted to understand the origin of the physical properties of different materials. I knew that I wanted to be a theorist because I enjoyed using math to explain physical phenomena. At the same, I have always found the world of biology fascinating.

My first research topic in the graduate school was related to superconductors. One day, I told my PhD advisor that I wish I could work on some projects relevant to biological systems. He suggested a few projects integrating my interest in physics to biology and I found them very interesting. I became very excited that we could use the methods of condensed matter physics to study various biological systems.

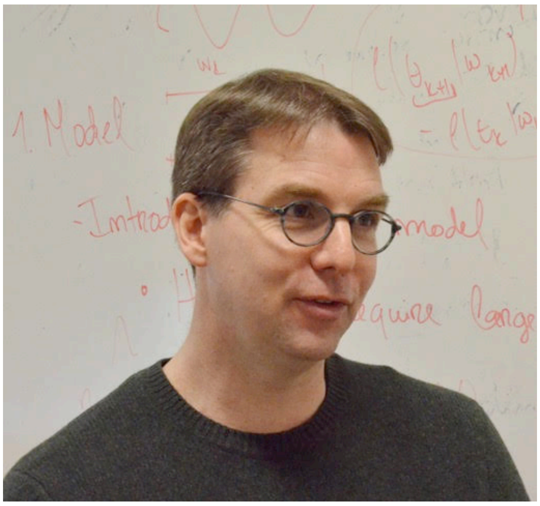
WHAT DO YOU HOPE TO DO NEXT?

There are still many mysteries lingering about the assembly of virus particles. Currently, I am working with my experimental collaborators to understand the assembly of coronaviruses like SARS-CoV-2. I will continue the training of the next generation of physicists working on the biologically motivated questions. We also continue our outreach program about the structure of viruses for K-12 students. Because of SARS-CoV-2, there is an increased public interest in learning more about viruses.

WHAT'S YOUR FAVORITE SCIENCE PAPER AND WHY?

One of my favorite science papers is by Crick and Watson (CW) (over 65 years ago!) about the structure of viruses: Crick, F., Watson, J. Structure of Small Viruses. Nature 177, 473–475 (1956). In the absence of cryo-electron microscopy images but based on simple and very elegant physical arguments, they discuss why viral shells must have highly symmetric structures. They note that given the small size of viral genomes, the capsids of viruses must be formed from a minimum number of gene products. In many cases, viral capsids are made from the assembly of many copies of a single protein. On this basis, CW argued that spherical viruses should actually be in the form of regular polyhedra ("platonic solids") all of whose faces are identical perfect polygons in which all protein units sit in identical environments. The largest shell of this kind is an icosahedron consisting of 60 equivalent proteins. Subsequent capsid structure determinations confirmed the special role of icosahedral symmetry, but also indicated that larger numbers of proteins were involved.

Meet the new APS Fellows!



Greg Stephens, VU Amsterdam and OIST Graduate University

CONTRIBUTION TO BIOPHYSICS COMMUNITY

To the biophysics community I think we showed that physical approaches could be productively applied to the movement of animals, and we helped create an intellectual community with similar interests. From our earliest work illustrating "eigenworms" in the roundworm C. elegans, to excitement that we see now, for example through the many March Meeting focus sessions related to behavior, we have helped create and nurture this new "physics of behavior" perspective.

WHAT GOT YOU INTERESTED IN BIOPHYSICS?

During my Ph.D., I trained in quantum gravity, and am very much a theoretical physicist with a deep drive for unifying principles. Then during a postdoctoral stay at Los Alamos National Laboratory, I was exposed to the study of the brain. And when I thought about all of the beautiful ideas in physics, I started to wonder; what is more fundamental, our unifying physical principles or the brain that discovers them? After that it was simply impossible NOT to think about living systems. I was also lucky enough to participate in a formative Methods in Computational Neuroscience summer course at the MBL in Woods Hole, and to engage with the welcoming quantitative biology and biophysics community at Princeton University, where I was a postdoc with Bill Bialek.

WHAT DO YOU HOPE TO DO NEXT?

We are pushing our research along two very different directions: first, connecting data-driven behavior analysis with bio-mechanical models. I am hopeful that, at least in simpler animals, such connections can illustrate a beautiful bridge between precision experiments, analysis and underlying theory. Second, expanding our repertoire of systems to explore just how complex in behavior we can go. For example we are currently analyzing the pair dynamics of adult zebrafish as they engage in dominance contests. Perhaps we can even quantitatively approach fundamental questions of our own human experience, which are traditionally reserved for the cognitive and psychological sciences.

WHAT'S YOUR FAVORITE SCIENCE PAPER AND WHY?

I don't have a single favorite science paper. But I especially like those with foundational ideas, simply explained. One example is Einstein's 1905 paper on Brownian motion, which is easily understood by undergraduate physics students.

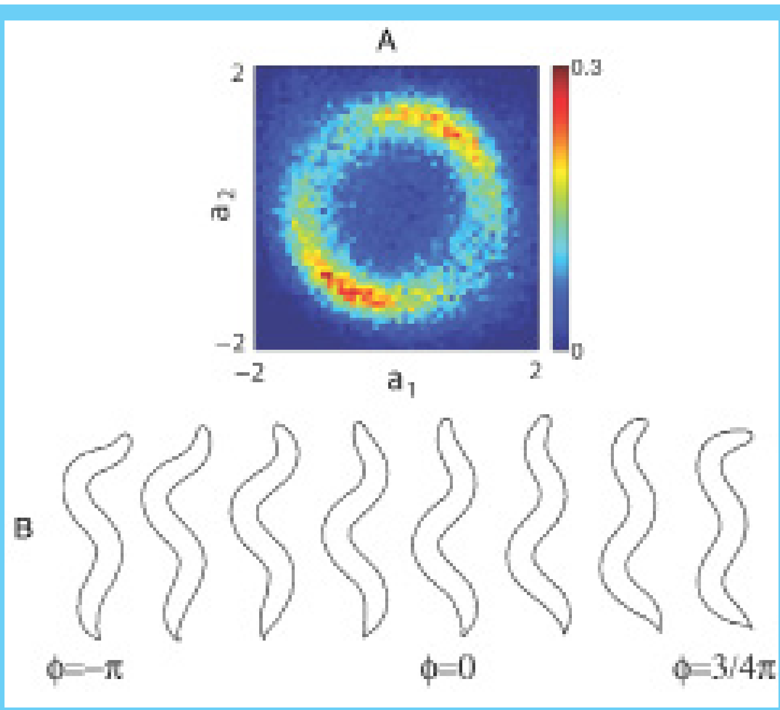


Figure taken from "Dimensionality and dynamics in the behavior of C. elegans", PLoS Comp Bio (2008). C. elegans images were subjected to PCA to make eigenworms, and the first two principal components (A) reveal oscillations shown in worm images in (B).

Meet the winner of the APS DBIO Max Delbruck Prize!

Arup Chakraborty, MIT

CONTRIBUTION TO BIOPHYSICS COMMUNITY

I think that I have contributed to the biophysics community in two ways. First, for over two decades, I have tried to develop and apply approaches rooted in statistical physics to study fundamental questions in immunology and then harness that knowledge toward practical ends. This work has often involved collaborations with immunologists, and several physicists have worked with me as students and postdoctoral fellows on these projects. Second, I have tried to play a role in creating forums that bring together biophysicists and immunologists; one example being the annual "Physical Concepts in Immunology" meetings that I have co-organized with Aleksandra Walczak and Michael Lassig - the location of this meeting rotates between Cambridge (MA) and Europe.

RELATEDLY, WHAT PAPER OF YOUR OWN IS YOUR FAVORITE AND WHY?

It is difficult for me to pick one favorite paper. Rather, I would cite three examples of topics that I have worked on with collaborators that have shed light on some immunological questions. First, work on the formation and function of the immune synapse (Qi et al, PNAS (2001); Lee et al, Science (2003)). Second, work (with collaborators) on how thymic development shapes the T cell repertoire (Kosmrlj et al, PNAS (2008); Kosmrlj et al, Phys. Rev. Lett. (2009); Kosmrlj et al, Nature (2010); Stadinski et al, Nature Immunology (2016)). Finally, work on developing the fitness landscape of HIV (Dahirel et al, PNAS (2011); Ferguson et al, Immunity (2013); Shekhar et al, Phys. Rev E (2013); Barton et al, Nature Comm (2016)).

I am also pleased by my work on transcriptional condensates as a regulatory mechanism (Hnisz et al, Cell (2017); Henninger et al, Cell (2021)).

WHAT GOT YOU INTERESTED IN BIOPHYSICS?

I did not work on biophysical questions until 1999. In October of 1999, Jay Groves showed me a paper in Science on the immune synapse because he thought that some of my past work on polymers and pattern recognition may be pertinent. I did not understand anything about the paper Jay showed me, but I realized it had nothing to do with my past work. In late December of 1999, I decided to read the synapse paper. It took me a few months to read it as I did not know the immunological vocabulary. My reading suggested that statistical physics-based approaches could help shed light on some of the key questions raised by the observations reported in the paper on the immune synapse. My work with postdoctoral fellows following this approach led to predictions that were tested positively by immunological collaborators. This got me very interested in immunology. I believe that statistical physics is a natural language for thinking about diverse emergent phenomena in immunology. I have worked with passion on immunological questions ever since.

WHAT DO YOU HOPE TO DO NEXT?

I am excited to continue my work on immunological questions that include evolution of antibodies against highly mutable pathogens and why autoimmunity is often triggered by persistent viral infections, as well as my work on transcription. I plan to continue to help bring together the community of "immunophysicists", which is now a rapidly growing group of scientists.

WHAT'S YOUR FAVORITE SCIENCE PAPER AND WHY?

Again it is difficult to pick a single paper. But, since I am forced to do so I will pick John Hopfield's paper on Kinetic Proofreading. There are two reasons why I like this paper: first, the principle of kinetic proofreading applies to diverse phenomena in biology; second, this paper emphasizes how non-equilibrium phenomena are critical for regulation of biological processes.

Calendar of upcoming events

19

Postdoc Training

MODERATOR: MOHAMMAD NOORANIDOOST

How does one get the most value out of their time as a postdoc in biophysics? What qualifies as "success" when you are a postdoc?

These questions and more will be answered in this workshop sponsored by APS DBIO. A panel of academicians at various career stages will provide their insights into the purpose of postdoctoral training and how it can be used to prepare biophysicists for their future careers. In addition, they will talk about their personal experiences as successful, former postdocs and provide the audience with advice about how to effectively interact with other biophysicists and interdisciplinary collaborators. How can you convey the important Physics that you're learning, while connecting to the biological insight that results? Join us to learn how to convey the importance and excitement about research breakthroughs in Biological Physics.

PANELISTS:

Debra Fadool, Hawa Racine Thiam, Eyal Karzbrun

5-10

APS March Meeting: In-person

20-22

APS March Meeting: Virtual

The American Physical Society's March Meeting brings together scientists and students from around the world to connect and collaborate across academia, industry, and major labs. Students, early-career physicists, and experienced professionals will benefit from the networking and learning at March Meeting.

Whether you join in-person or virtually, March Meeting 2023 is the perfect opportunity to share your research, network with other physicists, and learn about current issues relevant to the physics community.

The in-person March Meeting will be held in Las Vegas from March 5–10 2023. Registration now open.

The virtual 2023 March Meeting takes place online from March 20–22, 2023. Registration now open.

https://engage.aps.org/dbio/resources/workshops-networking