BP 4: Bacterial Biophysics

Time: Monday 9:30–11:15 Location: H46

Invited Talk BP 4.1 Mon 9:30 H46

Spatiotemporal organization of bacterial biofilm formation and functions — •Knut Drescher — Biozentrum, University of Basel, Basel, Switzerland

In nature, bacteria often live in three-dimensional communities termed biofilms, in which cells are attached to each other through an extracellular matrix. In this presentation, I will first introduce microscopy, image processing, and spatiotemporal transcriptome measurement techniques that enable us to monitor all individual cells in living biofilms. Based on these techniques, I will then show how we can identify the cell-cell interaction processes that determine the architecture development of biofilm microcolonies, across different species. I will then proceed to discuss how individual cells in biofilms coordinate their activities so that the biofilm community develops emergent functions, such as the predation of human immune cells, as well as the protection from viral predators. This talk will therefore shed light on the spatiotemporal development of bacterial communities, and the mechanisms underlying emergent functions of these communities.

BP 4.2 Mon 10:00 H46

Modelling the growth of biofilms on soft substrates — •Anthony Pietz[1], Uwe Thiele[1], and Karin John[2] — [1]Universität Münster, Münster, Germany — [2]Université Grenoble Alpes

Bacteria invade surfaces by forming dense colonies encased in a polymer matrix. Successful settlement of founder bacteria, early microcolony development and later macroscopic spreading of these biofilms on surfaces rely on complex physical mechanisms. Data show that on soft hydrogels, substrate rigidity is an important determinant for biofilm initiation and spreading. Using a thermodynamically consistent thin-film approach for suspensions on soft elastic substrates we investigate in silico the role of substrate rigidity in the osmotic spreading of biofilms. We show that on soft substrates spreading is considerably slowed down and may even be arrested depending on the biomass production rate. We find, that the slowing down of biofilm spreading on soft surfaces is caused by a reduced osmotic influx of solvent into the biofilm results from the coupling between substrate deformation and interfacial forces.

BP 4.3 Mon 10:15 H46

Dynamics of bacterial growth and colony development in heterogeneous mechanical landscapes — •Chenyu Jin[1] and Anupam Sengupta[1,2] — [1]Physics of Living Matter Group, Department of Physics and Materials Science, University of Luxembourg, 162 A, Avenue de la Faïencerie, L-1511, Luxembourg — [2]Institute for Advanced Studies, University of Luxembourg, Avenue de l'Université, L-4365, Esch-sur-Alzette, Luxembourg

Bacteria inhabit diverse confinements, experiencing different mechanical cues including surface stiffness and adhesion, friction and wettability [1]. Recent studies have revealed how local crowding and phenotypic noise impact bacterial growth and structural changes like the monolayer-to-multilayer transitions (MTMT)[2,3]. Yet how colonies proliferate in heterogeneous physical landscapes remain largely unknown [4]. Here we combine quantitative imaging and numerical modeling to compare the dynamics of colony growth within soft hydrogels with those in liquid media for different bacterial species. We find that the growth rate typically decreases across species, at both the colony and individual scales, while the critical area at the MTMT increases by an order of magnitude in the confined environment. An accompanying bioenergetic model offers mechanistic insights into the colony development in heterogeneous mechanical settings.

[1] NAM Araújo, LMC Janssen, et al., *Soft Matter* 19, 1695-1704 (2023). [2] R Wittmann, . . . , A Sengupta, *Commun. Phys.* 6, 331 (2023). [3] J Dhar, . . . , A Sengupta, *Nat. Phys.* 18, 945 (2022). [4] C Jin, A Sengupta, *Biophys. Rev.* 16, 2024

BP 4.4 Mon 10:30 H46

Capillary interactions organize bacterial colonies — •Ricard Alert[1,2,3], Matthew E. Black[4], Chenyi Fei[4,5], Ned S. Wingreen[4], and Joshua W. Shaevitz[4] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden — [2]Center for Systems Biology Dresden — [3]Cluster of Excellence Physics of Life, TU Dresden — [4]Princeton University — [5]Massachusetts Institute of Technology

Many bacteria inhabit hydrated environments like soil, textiles and agar hydrogels in the lab. In these environments, cells are surrounded by a water meniscus, and they experience capillary forces. I will show that capillary forces organize bacterial colonies, enabling cells to aggregate into densely packed nematic layers while still allowing them to slide past one another. Our collaborators developed an experimental apparatus that allows us to control bacterial collective behaviors by varying the strength and range of capillary forces. Our results suggest that capillary forces may be a ubiquitous physical ingredient in shaping microbial communities in partially hydrated environments.

BP 4.5 Mon 10:45 H46

CISS Effect in Bacterial Extracellular Electron Transfer — •Nir Sukenik[1], Mohamad El Naggar[1], Yossi Paltiel[2], Ron Naaman[3], and Lech Tomasz Baczewski[4] — [1]University of Southern California, Lis Angeles, CA, USA — [2]Hebrew University of Jerusalem, Jerusalem, Israel — [3]Weizmann Institute of Technology, Rehovot, Israel — [4]Polish Academy of Sciences, Warsaw, Poland

Electron transfer through chiral molecules is characterized by a coupling between the electron velocity and its spin through the Chirality Induced Spin Selectivity (CISS) effect. Since most biomolecules are homochiral, it was recently hypothesized that CISS underlies the highly efficient electron transfer observed in biological systems by reducing the probability of electron backscattering. A remarkable example of efficient long-distance electron transport in biology is the extracellular respiration of metal-reducing bacteria, where a pathway composed of multiheme cytochromes facilitates extracellular electron transfer (EET) from the cellular interior to external electrodes. Using conductive probe atomic force microscopy measurements of protein monolayers adsorbed onto ferromagnetic substrates, we show that electron transport is spin selective in two of the multiheme cytochromes, the membrane-associated decaheme MtrA and the tetraheme periplasmic STC. To assess the in vivo physiological impact of CISS, we also present evidence that the respiration of a different EET capable bacterium, depends on the magnetization direction of the underlying ferromagnetic electrode. Taken collectively, our results demonstrate the important role of spin in a biological mechanism essential to life.

BP 4.6 Mon 11:00 H46

Slower prior growth in E. coli confers a competitive advantage under carbon starvation — •Zara Gough[1], Hamid Seyed Allaei[1], Severin Schink[2], Elena Biselli[1], Sophie Brameyer[3], and Ulrich Gerland[1] — [1]Physics of Complex Biosystems, Physics Department, Technical University of Munich, 85748 Garching, Germany — [2]Department of Systems Biology, Harvard Medical School, 200 Longwood Ave, Boston, MA 02115, USA — [3]Microbiology, Faculty of Biology, Ludwig Maximilians University Munich, Martinsried, Germany

Bacteria spend much of their life cycle under nutrient limitation, competing for resources to survive. Recent research has quantitatively characterized the carbon starvation kinetics of E. coli in monoculture using two experimentally measurable parameters: the maintenance rate and the recycling yield. Building on this framework, we show that these same parameters can predict fitness changes when cultures with distinct prior growth rates are subjected to starvation in co-culture. We introduce an additional model that explores the interaction between intracellular energy reserves and extracellular medium energy during co-culture starvation, and accounts for different uptake rates resulting from prior growth rate. Using a bottom-up approach to modelling that is derived directly from bacterial physiology, our work extends the quantitative understanding of population dynamics in E. coli.