LadHyX Seminar – April 2nd, 10:45

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How transport mechanisms shape microbial life: from biofilm dynamics in porous media to bacterial genotoxin in the gut

Transport processes and mechanical forces play a central role in shaping microbial communities, governing nutrient delivery, toxin distribution, cell dispersal, attachment to and detachment from surfaces, and biofilm formation. In this talk, I will present recent work exploring these couplings across two distinct biological contexts.

In the first part, I will discuss the spatiotemporal dynamics of bacterial biofilms in porous media. Combining microfluidic experiments with mathematical modeling, we study how Pseudomonas aeruginosa biofilms interact with flow in pore networks. We show that nonlocal hydrodynamic interactions drive the self-organization of biofilms into clusters of clogged channels separated by preferential flow paths. We further demonstrate that these paths are inherently unstable: while continuous shear stress alone does not cause catastrophic failure, flow redistribution through the network generates pressure differentials across clogged regions that, when exceeding critical thresholds, trigger large-scale detachment events. We propose that this sensitivity reflects an evolutionary trade-off between mechanical robustness and nutrient accessibility, providing a multiscale perspective on bacterial fitness in porous environments.

In the second part, I will present ongoing work on colibactin, a genotoxin produced by pks+ Escherichia coli strains implicated in colorectal cancer and in bacterial warfare in the gut microbiota. Colibactin is known to be extremely unstable and its genotoxic activity has long been considered strictly contact-dependent. Using a model system combining pks+ E. coli with SOS-reporter target bacteria, we investigate the effective range of colibactin-mediated DNA damage and present evidence for remote, diffusion-mediated interactions between bacterial colonies separated by distances exceeding typical cell-contact scales. These findings raise new questions about how transport, here dominated by diffusion and degradation, controls the spatial range of genotoxic weapons.