Microbial Treasure Hunt: How Bacteria and Viruses Find their Haven

Jyot Antani, PhD
Current affiliation: Postdoc at Quantitative Biology Institute, Yale University (USA)
PhD (2021) from Department of Chemical Engineering, Texas A&M University (USA)

Life at low Reynold's number is vastly different from our Newtonian world. Therefore, Bacteria and Viruses experience their surroundings and search for their targets in a very different manner. Studying the dynamics of microbial niche-finding processes offers biomedical and technological advantages.

My doctoral work focused on bacterial motility, which is powered by the rotation of thin helical appendages called flagella. Each flagellum is rotated by a transmembrane flagellar motor. Switching in the direction of the motor rotation enables navigation in response to chemical signals (that is, chemotaxis) which helps the cell swim to favorable environments. The flagellar motor has also been implicated in tactile sensing of surfaces, which represents earliest steps in surface-colonization. The signaling events that lead from surface-sensing to colonization are unknown. In an effort to describe these mechanisms, we studied the effect of mechanical forces on the chemotaxis-output of the motor. Our results indicate that mechanical force on the motor regulates its sensitivity to intracellular chemical signals, by controlling the affinity for CheY-P, a major chemotaxis protein. These findings explain how bacteria can robustly target different niches irrespective of the fluctuations in the mechanical environment. This work addressed fundamental problems in bacterial pathogenesis and biofilm formation, which are major biomedical challenges.

Viruses are not actively motile, yet they target specific receptors on host surfaces. My postdoctoral research concerns phages, viruses of bacteria, which are emerging as promising therapeutics to treat multi-drug-resistant bacterial infections, a major biomedical challenge. An important determinant of phage therapy efficacy is the attachment (adsorption) efficacy of phages to the host bacterial surface. The classical understanding of phage adsorption is derived from flasks- and plate-based assays, which provide ensemble estimates of the adsorption rate. I have developed a fluorescence microscopy-based assay to quantify the attachment of individual phages to cells. Comparisons of the classical adsorption rate to the microscopic measurements revealed a monotonic relationship, suggesting that the microscopy assay can be used as a proxy for the labor-intensive petri-plate-based assay. Moreover, this work has established a framework for visualizing the dynamics of the interactions between individual viruses and the host surface, which will allow us to model, parametrize, and quantify the individual steps in the viral target search process.