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Surfing the Wave: How Bacteria Migrate through Porous Media

TAPOMOY BHATTACHARJEE, Andlinger Center for Energy and the Environment, Princeton University, DANIEL AMCHIN, FELIX KRATZ, SUJIT DATTA, Department of Chemical and Biological Engineering, Princeton University — While bacterial motility is well-studied for motion on flat surfaces or in unconfined liquid media, most bacteria are found in heterogeneous porous media, such as biological gels and tissues, soils, and sediments. However, it is unknown how pore-scale confinement alters bacterial motility, because the opacity of typical 3D media precludes direct visualization. Here, we reveal that the paradigm of run-and-tumble motility is dramatically altered in a porous medium. By directly visualizing individual *E. coli*, we find a new form of motility in which cells are intermittently and transiently trapped as they navigate the pore space; analysis of these dynamics enables prediction of single-cell transport over large length and time scales. Moreover, we show that concentrated populations can collectively migrate through a porous mediumdespite being strongly confinedby chemotactically surfing a self-generated nutrient gradient. This behavior depends sensitively on pore-scale confinement, initial colony density, and nutrient consumption, providing a means to control collective migration in bacterial populations. Our work provides a revised picture of active matter transport in complex media, with implications for healthcare, agriculture, and bioremediation.

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