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Nematic Ordering in a Population of Growing and Dividing Rod-like Cells[1]

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Morphogenesis is one of the most important themes in biology, and it is also central to nonequilibrium physics. The fundamental issue is to understand how local interactions of elementary components lead to collective behavior and the formation of a highly organized system. In nature this self-organization is found on many different scales, from single cells to schools of fish and herds of animals. Collective behavior leads to significant selective advantages for living organisms. At low density, communication among cells occurs mainly due to chemotaxis, the mechanical response of cell to the gradients of chemicals emitted by other cells. At higher densities, steric exclusion effects may strongly affect their collective behavior. In this work we focus on the mechanical interaction among non-motile bacteria in engineered biofilms. These biofilms are formed by growing two-dimensional bacterial colonies in a highly controlled microfluidic environment. We combine experimental observations and analysis with discrete-element molecular dynamics simulations and theoretical modeling to provide mesoscopic description of the biofilm growth. Our results reveal how cell growth and colony expansion trigger the formation of the orientational (nematic) order in the biofilms.

[1]In collaboration with D. Volfson. S. Cookson, and J. Hasty, University of California, San Diego.