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The Fractal Evolution of Bacillus subtilis biofilm

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Abstract: Biofilms are clusters of bacteria wrapped in extracellular matrix and polymers. The study of biofilm morphological transformation has been around for a long time and has attracted widespread attention. In this talk, we present a model for biofilm growth based on the interaction force, in which bacteria are treated as tiny particles and locations of particles are updated by calculating the repulsive forces among particles. We adapt a continuity equation to show nutrient concentration variation in the substrate. Based on the above, we study the morphological transformation of biofilms. We find that nutrient concentration and nutrient diffusion rate dominate different biofilm morphological transition processes, in which biofilms would grow into fractal morphology under the conditions of low nutrient concentration and nutrient diffusivity. At the same time, we expand our model by introducing a second particle to mimic extracellular polymeric substances (EPS) in biofilms. We find that the interaction between different particles can lead to phase separation patterns between cells and EPSs, and the adhesion effect of EPS can attenuate this phenomenon. In contrast to single particle system models, branches are inhibited due to EPS filling in dual particle system models, and this invalidation is boosted by the enhancement of the depletion effect.

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