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Diffusion-mediated growth rules allow assembly of metabolically efficient colony YIPEI GUO, MIKHAIL TIKHONOV, MICHAEL P. BRENNER, Harvard University — The typical self-assembly program examines how specific interaction rules can lead to the assembly of desired structures from individual building blocks. This is a natural approach when looking at macromolecular structures that are held together by molecular interactions. However, spatially-structured colonies such as biofilms emerge from cell growth, analogous to allowing building blocks to replicate. The final arrangement of different cell types depends on the response of these cells (switching between states, growth rate, etc.) to local concentrations of diffusible chemicals such as metabolites and morphogens. Here we consider the simplest possible set of rules that can arise in a colony of cells that exchange intermediates and carry out an overall reaction. We found that incorporating diffusion-mediated growth rules into the colony's self-assembly program not only gives rise to a diverse range of structures, it can also solve the optimization problem of achieving the metabolically most efficient structure. While agent-based simulations have commonly been used to explore the effect of specific interaction mechanisms, this self-assembly perspective brings new types of questions: what structures are easier to assemble, what structures can be obtained with a minimal set of rules.

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