Synthetic cell-cell adhesins and 4-bit logic for programming multicellular interface patterns

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Multicellular systems, from bacterial biofilms to human organs, form spatial patterns and interfaces to achieve complex functionality, promising applications like programmable biomaterials, artificial tissues, and metabolic consortia [1]. Our ability to rationally engineer such active matter is still limited. My lab recently developed the first synthetic and optogenetic approaches to control cell-cell and cell-surface adhesion for bacterial self-assembly [2] and patterning ('Biofilm Lithography') [3].

I will discuss the biophysical characterization of these tools and their applications to investigate cooperative antibiotic responses in biofilms. I will then demonstrate a synthetic 4-bit cell-cell adhesin logic to experimentally program and mathematically model universal two-dimensional interface patterns [4]. These interfaces are generated through a swarming adhesion mechanism that enables precise control over interface geometry as well as adhesion-mediated analogs of developmental organizers and morphogen fields. Utilizing tiling and four-color mapping concepts, I present algorithms for creating versatile target patterns. Remarkably, a minimal set of four adhesins suffices to program arbitrary tessellation patterns, implying a low critical threshold for the engineering and evolution of complex multicellular systems.

Finally, I will discuss ongoing and future project opportunities in my lab – particularly for modeling genetic networks, biofilms, and bioreactors with applications for chemical synthesis, green-house gas reduction (methane), and bioremediation

References

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