Synthetic Patterns: Sequential Establishment of Stripe Patterns in an Expanding Cell Population

Chenli Liu[1], Xiongfei Fu[2], Leihan Tang[3], Peter Lenz[4], Wei Huang[1,2], Terence Hwa[5], Jian-Dong Huang[1]

[1]*The University of Hong Kong, Biochemistry, Hong Kong*
[2]*The University of Hong Kong, Physics, Hong Kong*
[3]*Hong Kong Baptist University, Physics, Hong Kong*
[4]*University of Marburg, Department of Physics and Center for Synthetic Microbiology, Germany*
[5]*University of California at San Diego, Center for Theoretical Biological Physics, USA*

Sequential and periodic patterns are recurring anatomical features in living organisms. Their rhythmic dynamics and intriguing beauty have fascinated generations of scientists. However, the understanding of the underlying mechanisms is hindered by the overwhelming molecular complexities in most cases. Engineered synthetic systems can simplify the complexities and refine the theoretical assumptions, thereby providing insights into the principles of naturally occurring phenomena. Here we described a synthetic pattern formation system by simply coupling cell density and motility, which enabled the programmed cells to form crisp, periodic stripes of high- and low- densities in a sequential and autonomous manner. Theoretical and experimental analyses revealed that the periodic structure arises from a recurrent aggregation process generated during the continuous expansion of the cell population. In accordance with our model prediction, patterns with different numbers of stripes were generated by tuning the activity of a single promoter. The results establish motility control as a simple, potent route for generating regular spatial structures without the need of a pacemaker, and illustrate the utility of synthetic genetic systems in studying pattern formation in spatially extended systems.