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Self-Organization of Bacterial and Human Populations: Same Model, Different Scale

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The direct movement of organisms toward a chemoattractant and away from a chemorepellent is called chemotaxis. Since the pioneering work of Keller and Segel, published in 1970, the dynamics of chemotactic population and chemoattractant are usually modelled mathematically using a system of nonlinear equations of the reaction-diffusion-chemotaxis type. Although the chemotaxis-type models are mostly applied in biology, they have also been applied to solve problems in various other fields, including the social sciences. Neto and Claeyssen have applied a chemotaxis model to describe economic growth containing capital-induced labour migration. Short et al. proposed a chemotaxis-type system to describe the movement of criminals toward increasing concentrations of an attractiveness value. In this work, the chemotaxis-based self-organization and patterning relationship between bacterial and human populations were investigated computationally. The pattern formation in luminescent suspensions of E. coli was studied as an example of bacterial self-organization. Two aspects of human social behaviour were also analysed: the formation of economic agglomerations, which are regions with higher levels of capital and labour force than their neighbours, and the formation of crime hotspots, when criminals move toward a higher concentration of an attractiveness value. Nonlinear two- and one-dimensional-in-space reaction-diffusion-chemotaxis models were used to simulate the pattern formation in all three chemotactic populations living within a restricted area - a circle. The numerical simulation was carried out using the finite difference technique. Although bacterial self-organization and geographical migration of the human population have large differences, both movements share close similarities except for the difference in scale.