Nonlinearity and Stochasticity in Emergent Phenomena II

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*Bacterial swimming and collective dynamics in bacterial colonies**

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We examine two species of rod-shaped motile bacteria that are commonly found in soil. Bacteria swimming [1] within a growing colony are observed to exhibit collective motion (swarming) [2] and large non-thermal number fluctuations [2]. We find that the correlations between neighboring bacteria swimming in a cluster exhibit, surprisingly, the *same* scale invariant correlations that were observed for flocks of starlings flying in Rome (Cavanaga et al. *PNAS* **107**, 2010), even though the interaction mechanisms for the bacteria and starlings are completely different [3].

When neighboring colonies of the rod-shaped motile bacteria grow and approach one another, we observe that the growth slows and stops. Analysis of the gel between the competing colonies reveals the presence of a lethal protein secreted by the colonies [4]. The immediate question is why doesn't this toxin kill the bacteria secreting it? A mathematical model helps answer this question. Further, sub-lethal concentrations of the toxin are found to induce the rod-shaped bacteria to switch to a spherical shape that is resistant to the toxin and to other antibiotics [5]. Thus the bacteria adapt to adverse environmental conditions by a change in form; this change is reversible if favorable conditions are encountered.

*Research conducted with co-authors in the following:

[1] B Rodenborn et al. *PNAS* **110** (2013).

[2] HP Zhang et al., *PNAS* **107** (2010).
[3] X Chen et al., *Phys. Rev. Lett.* **108 (**2012).
[4] A Be’er et al., *PNAS* **107** (2010).
[5] A Be’er et al., *mBio* **2**, 3 (2011).