Cell flexibility affects the alignment of model myxobacteria

Albertas Janulevicius[1], Mark C.M. van Loosdrecht[1], Angelo Simone[2] and Cristian Picioreanu[1]

***Short Abstract* — Myxobacteria exhibit a complex life cycle culminating in the development of multicellular fruiting bodies. The alignment of myxobacteria cells within populations is crucial for the development to proceed. Here we created a computational mass-spring model of a flexible rod-shaped cell that glides on a substratum. We found that a flexible cell powered by engine force at the rear of the cell, as suggested by the slime extrusion hypothesis for myxobacteria motility engine, would not be able to glide in the direction of its long axis. A population of rigid cells could align due to mechanical interactions between cells, but cell flexibility impaired the alignment.**

***Keywords* — myxobacteria, motility, alignment, modeling**

Myxobacteria are social bacteria that exhibit a complex life cycle culminating in the development of multicellular fruiting bodies [1]. The alignment of rod-shaped myxobacteria cells within populations is crucial for the development to proceed [2]. It has been suggested that myxobacteria align due to mechanical interactions between gliding cells and that cell flexibility facilitates reorientation of cells upon mechanical contact [3,4]. However, these suggestions have not been based on experimental or theoretical evidence. Here we created a computational mass-spring model of a flexible rod-shaped cell that glides on a substratum periodically reversing the direction. The model was formulated in terms of experimentally measurable mechanical parameters, such as engine force, bending stiffness and drag coefficient. We investigated how cell flexibility and motility engine type affected the pattern of cell gliding and the alignment of a population of 500 mechanically interacting cells. It was found that a flexible cell powered by engine force at the rear of the cell, as suggested by the slime extrusion hypothesis for myxobacteria motility engine [5], would not be able to glide in the direction of its long axis. A population of rigid reversing cells could indeed align due to mechanical interactions between cells, but cell flexibility impaired the alignment.

[1]Environmental Biotechnology Group, Department of Biotechnology, Delft University of Technology, Julianalaan 67, 2628 BC, Delft, The Netherlands. E-mail: albertas.janulevicius@centras.lt

[2]Faculty of Civil Engineering and Geosciences, Delft University of Technology, P.O. Box 5048, 2600 GA, Delft, The Netherlands

REFERENCES

[1] Kaiser D (2003). Coupling cell movement to multicellular development in myxobacteria. Nat. Rev. Microbiol. 1:45-54.

[2] Kim SK and Kaiser D. (1990). Cell alignment required in differentiation of Myxococcus xanthus. Science 249:926-928.

[3] Wall D and Kaiser D. (1998). Alignment enhances the cell-to-cell transfer of pilus phenotype. Proc. Natl. Acad. Sci. U.S.A. 95:3054-3058.

[4] Kaiser D and Welch R. (2004). Dynamics of fruiting body morphogenesis. J. Bacteriol. 186:919-927.

[5] Wolgemuth C, Hoiczyk E, Kaiser D and Oster G. 2002. How myxobacteria glide. Curr. Biol. 12:369-377.