

# Bacterial strategies for chemotaxis response

Antonio Celani<sup>1</sup>

Institut Pasteur, 25-28, Rue du Docteur Roux 75724 Paris Cedex 15 FRANCE  
celani@pasteur.fr

Regular environmental conditions allow for the evolution of specifically adapted responses, whereas complex environments usually lead to conflicting requirements upon the organism's response. A relevant instance of these issues is bacterial chemotaxis, where the evolutionary and functional reasons for the experimentally observed response to chemoattractants remain a riddle. Sensing and motility requirements are in fact optimized by different responses, which strongly depend on the chemoattractant environmental profiles. It is not clear then how those conflicting requirements quantitatively combine and compromise in shaping the chemotaxis response. Here we show that the experimental bacterial response corresponds to the maximin strategy that ensures the highest minimum uptake of chemoattractants for any profile of concentration. We show that the maximin response is the unique one that always outcompetes motile but nonchemotactic bacteria. The maximin strategy is adapted to the variable environments experienced by bacteria, and we explicitly show its emergence in simulations of bacterial populations in a chemostat. Finally, we recast the contrast of evolution in regular vs. complex environments in terms of mini- max vs. maximin game-theoretical strategies. Our results are generally relevant to biological optimization principles and provide a systematic possibility to get around the need to know precisely the statistics of environmental fluctuations.