The role of motility gradients in proliferating active matter: the case of sibling inhibition in *Pseudomonas aeruginosa* bacteria

Dario Buonomo[*,a], **Giacomo Frangipane**[b,c], **Marco Polin**[d,e], **Fabio Bruni**[a], **Francesco Imperi**[a], **Barbara Capone**[a]

[a] *Department of Science, Roma Tre University,via della vasca navale 84, Rome, Italy*

[b] *Department of Physics, Sapienza University, piazzale Aldo Moro, Rome, Italy*

[c] *NANOTEC-CNR, Soft and Living Matter Laboratory, Institute of Nanotechnology, Italy*

[d] *Instituto Mediterráneo de Estudios Avanzados (IMEDEA), CSIC-UIB. Miquel Marquès 21, Esporles, Balearic Islands, Spain*

[e] *Departament de Física, Universitat de Les Illes Balears, 07071, Palma, Balearic Islands, Spain*

ABSTRACT

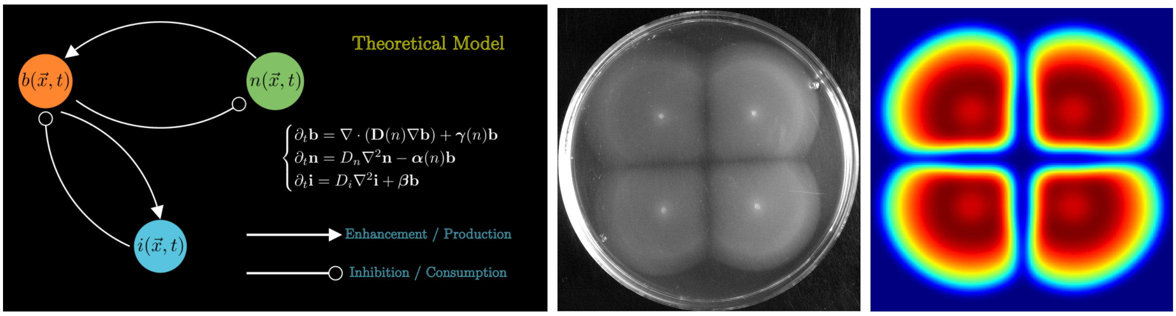

FIGURE 1. **Left:** Schematic representation of the theoretical model; **Center:** Experimental sibling inhibition; **Right:** Simulation of sibling inhibition

The ability of bacteria to swim in liquids or swarm on semi-solid surfaces, gels, porous media, and tissues is essential for colonising new territories, finding nutrients, and avoiding toxins.
Sometimes sibling colonies avoid each other just as they tend to avoid antibiotics thus forming distinct demarcation lines (DLs) between them. Although this phenomenon has been reported in literature, it is far from being understood[1–5]. We address this problem both experimentally and with numerical simulations.

Using a custom-built setup, we demonstrate that DLs are not associated to cell death [1], nor to quorum sensing (QS) signals or gel deformations [3]. We also show how colonies merge at different nutrient concentrations thus confirming the role of nutrient consumption in sibling inhibition. However, an irregular evolution profile that emerges at high nutrient concentrations does not allows the presence of a non-lethal inhibitory factor to be completely ruled out.

We model these collective behaviours with a Fisher-Kolmogorov type model using reaction-diffusion equations $\partial_t \mathbf{b} = \nabla\cdot(\mathbf{D}(n)\nabla\mathbf{b}) + \boldsymbol{\gamma}(n)\mathbf{b}$. In such a model, the diffusion and replication coefficients depend on the local concentration of nutrients $n(x,t)$.

[*] Presenting author.

In doing so, we deal with space- and time-dependent diffusivity $\mathbf{D}(x,t)$ and replication $\boldsymbol{\gamma}(x,t)$. We calibrate this model to experiments in homogeneous environments, thus decoupling motility and proliferation to study separately how they are influenced by nutrient concentration.

REFERENCES

[1] A. Be'er, H.P. Zhang, E. Florin, S.M. Payne, E. Ben-Jacob, H.L. Swinney, *Deadly competition between sibling bacterial colonies*, *Proc. Natl. Acad. Sci. U.S.A.*,**106 (2)** (2009) 428-433.

[2] Sekowska A, Masson JB, Celani A, Danchin A, Vergassola M. *Repulsion and metabolic switches in the collective behavior of bacterial colonies*, *Biophys J.* 5;97(3)(2009)688-98.

[3] Espeso DR, Martínez-García E, de Lorenzo V and Goñi-Moreno Á , *Physical Forces Shape Group Identity of Swimming Pseudomonas putida Cells.*, *Front. Microbiol.*,**7:1437** (2016)

[4] Rajorshi Paul, Tanushree Ghosh, Tian Tang and Aloke Kumar , *Rivalry in Bacillus subtilis colonies: enemy or family?*, *Soft Matter*,**15 (27)** (2019) 428-433.

[5] Kastrat, E., Cheng, HP. , *Escherichia coli has an undiscovered ability to inhibit the growth of both Gram-negative and Gram-positive bacteria.*, *Sci Rep*,**14, 7420** (2024)