Active modification of single and collective cell motion in model micro-colonies of Dictyostelium discoideum cells

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Dictyostelium discoideum is an amoeba that lives as a unicellular organism in the presence of nutrients. In that state, named vegetative state, the cells proliferate exponentially and move along persistent random trajectories with no cell-cell adhesion [1]. Cells are interacting with each other by transient physical contacts, as well as using quorum sensing mechanisms, that regulate cell motion with cell density [2]. To investigate the interplay of proliferation, random motion and cell-cell interactions in the collective dynamics of a population of cells, we make model circular micro-colonies of controlled shape, dimensions and density using PDMS microstencils technique [3] **(Figure 1, A, C).**

We quantify the spreading of such colonies and relate the single trajectories' properties to the macroscopic evolution of the system through statistical and mean-field analysis.

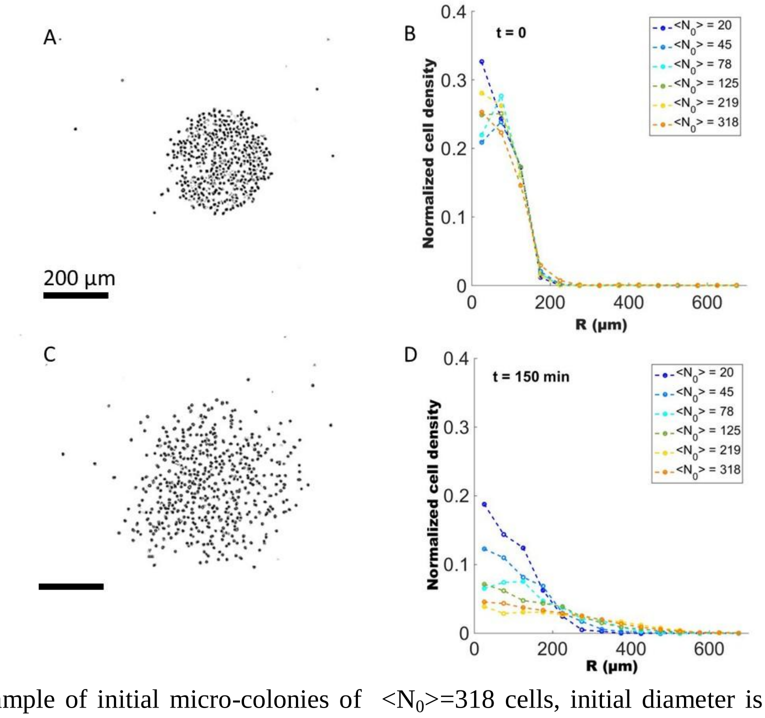

Figure 1: (A) Example of initial micro-colonies of $\langle N_0 \rangle$=318 cells, initial diameter is 320 µm, after image binarisation (each black dot correspond to an individual cell), **(B)** Initial normalized cell density as a function of radius R, for different initial cell number $\langle N_0 \rangle$, **(C)** Example micro-colonies spreading after 150 min for $\langle N_0 \rangle$=318 cells, (D) Normalized cell density as a function of radius R, for t=150 min.

The spreading of the colonies is density-dependent, with an increase in spreading rate with density **(Figure 1, B, D)**. In addition, at short times, we clearly show the apparition of a net radial velocity**,** indicating that the spreading of the colonies does not obey Fick's law and cannot be modeled by simple Brownian diffusion. This effect may be related to "Contact Inhibition of Locomotion" mechanisms already reported [4,5] , as well as modification of cell persistence upon contacts with other cells.

The experimental results obtained were compared to individual-based simulations of active Brownian particle. To be able to reproduce experimental results, active asymmetric reorientation has to be taken into account. We suggest a model where short-range interactions alone can account for short-times collective effect, while quorum-sensing factors are dominating at long times.

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