Causes and consequences of asynchrony in *D. discoideum* multicellular development

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***Short Abstract* — The life cycle of the social amoeba *Dictyostelium discoideum* includes a starvation-induced transition to aggregative multicellularity. During aggregation, however, amoebae do not coordinate perfectly and some of them remain solitary (loners). Combining experiments and modeling, we show that the loner-aggregator partitioning behavior is characteristic of each genetic variant and could be, potentially, shaped by natural selection. Finally, we discuss how interactions between partitioning behaviors could affect *D. discoideum* diversity when two genetic variants co-occur and develop in mixes as compared to segregated development.**

***Keywords* — Multicellular development, cell aggregation, quorum sensing, synchronization**

I. Purpose

In the social amoebae *Dictyostelium discoideum,* starvation triggers the partitioning of a population of free-living cells into aggregators, which ultimately develop a multicellular fruiting body made of dead stalk cells and reproductive spores, and non-aggregators, which remain as vegetative cells. While the emergence and functioning of the multicellular phase has been extensively investigated [1-3], it has been only recently that the asocial component, represented by non-aggregating (loner) cells, has captured some attention [4-6]. Loners are less resistant to starvation than spores, but they persist for some time and will eventually recover the multicellular stage in a subsequent starvation event. In addition, according to recent theoretical work, loners could provide selective benefits in stochastic environments and, when coupled with environmental heterogeneity (seasonality or spore dispersal across different patches) could contribute toward the rich diversity of *D. discoideum* observed in nature [4,7].

However, despite this potential importance of loners, the question of whether they are an unavoidable consequence of large-scale synchronization events or a heritable component of *D. discoideum* life-history remains unanswered. In this presentation, I will first show, using experimental results, that aggregation, and therefore the population partitioning between aggregating and non-aggregating cells, is a heritable population-partitioning process, with different genetic variants differing in their partitioning behavior. To explain these experimental results, I will introduce an individual-based model for the aggregation process, showing that the loner-aggregator partitioning could be the result of the population responding in an imperfectly synchronized manner during the developmental process. Finally, I will move the discussion to scenarios in which two genetic variants co-occur and mix, which results in interactions between their developmental programs that could profoundly impact the diversity of the species.

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References

[1] Bonner, J. T. The Social Amoebae: The Biology of Cellular Slime Molds. (Princeton University Press, 2009)

[2] Gregor, T., Fujimoto, K., Masaki, N. & Sawai, S. The onset of collective behavior in social amoebae. Science 328, 1021–1025 (2010).

[3] Strassmann, J. E. & Queller, D. C. Evolution of cooperation and control of cheating in a social microbe. Proceedings of the National Academy of Sciences 108, 10855–10862 (2011).

[4] Dubravcic, D., van Baalen, M. & Nizak, C. An evolutionarily significant unicellular strategy in response to starvation stress in Dictyostelium social amoebae. F1000Res 3, 133 (2014).

[5] Tarnita, C. E., Washburne, A., Martinez-Garcia, R., Sgro, A. E. & Levin, S. A. Fitness tradeoffs between spores and nonaggregating cells can explain the coexistence of diverse genotypes in cellular slime molds. Proceedings of the National Academy of Sciences 112, 2776–2781 (2015).

[6] Martinez-Garcia, R. & Tarnita, C. E. Lack of Ecological and Life History Context Can Create the Illusion of Social Interactions in *Dictyostelium discoideum*. PLoS Comput. Biol. 12, e1005246 (2016).

[7] Martinez-Garcia, R. & Tarnita, C. E. Seasonality can induce coexistence of multiple bet-hedging strategies in *Dictyostelium discoideum* via storage effect. J. Theor. Biol. 426, 104–116 (2017)