Adventurous bacteria

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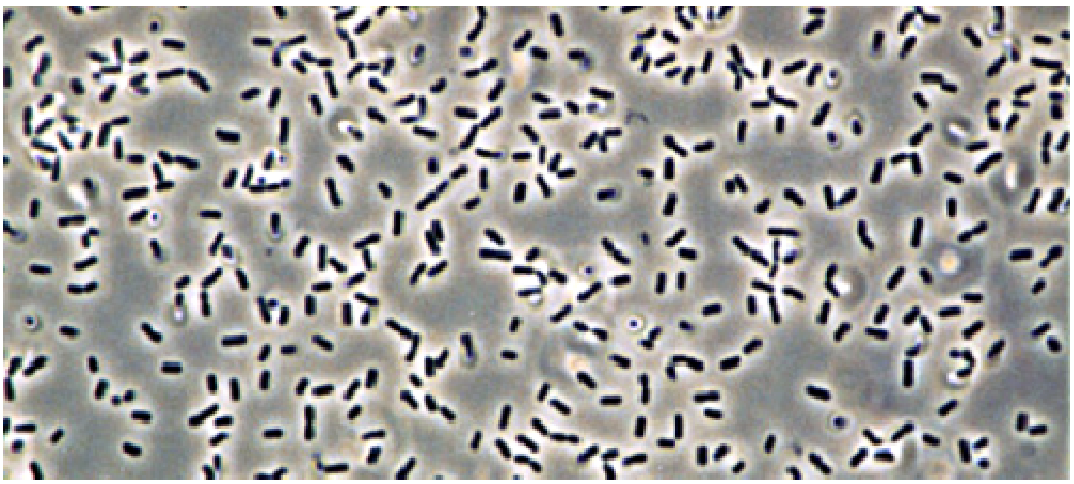

Bacillus Subtilis. Credit: Kookaburra / Wikipedia.

To reproduce or to conquer the world? Surprisingly, bacteria also face this problem. Theoretical biophysicists at Ludwig-Maximilians-Universitaet (LMU) in Munich have now shown how these organisms should decide how best to preserve their species.

The bacterium *Bacillus subtilis* is quite adaptable. It moves about in liquids and on agar surfaces by means of flagella. Alternatively, it can stick to an underlying substrate. Actually, the bacteria proliferate most effectively in this stationary state, while motile bacteria reproduce at a notably lower rate.

In order to sustain and extend the colony, bacteria primarily require sufficient nutrients. Moving slowly would mean that nutrients are soon used up, but adventurous bacteria that decide to move out fast in search of the land of Cockaigne may end up feeling lonely.

"Should I stay or should I go?"

Which strategy offers the best prospects for the organisms? Should one specialize in growth or migration, or be a generalist and steer a balanced course? This is the question that has been addressed by theoretical biophysicists in LMU Professor Erwin Frey's group at the NIM (Nanosystems Initiative Munich). "We have developed a special mathematical model in which these strategies compete with each other," explains Matthias Reiter, first author of the study. "And this model enables us to prove that generalists are most successful."

Up to now such experiments have only been performed on homogeneous bacterial cultures consisting of genetically identical cells. The LMU theorists are the first to calculate the behavior of heterogeneous *Bacillus subtilis* populations. For this purpose, they assign a fixed migration rate to each bacterium, which is inherited by its progeny. This rate determines the proportion of time the organisms spend in a motile state, as opposed to being engaged in nutrient uptake and proliferation. In the simulated scenario, the bacteria are, for instance, seeded at the center of a plate containing nutrients. They gradually consume the nutrients available locally and are forced to colonize unpopulated territory.

Fighting for the best spots

The model reveals that, initially, there is intense competition for the limited resources at the edge of the occupied territory. During this phase, individuals that reproduce fast and occupy as much space as possible are at an advantage. But they are soon superseded by colonies of generalists, which devote equal time to migration and proliferation. These gradually spread out, forming sectors as shown in the Figure.

The Munich theorists explain this behavior in terms of the invasion speed of so-called Fisher fronts. This speed is maximal in the case of a balance between growth and motility. Initially, colonies that steer a middle course form individual sectors, until they eventually occupy the entire invasion front.

"We intend to test our findings experimentally in cooperation with biologists, in order to compare our theory with experimental work," Erwin Frey says. "It would even be possible to extend the model to more complex ecosystems, since it can, in principle, be transferred to all range-expansion phenomena in which growth and motility are complementary skills."

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