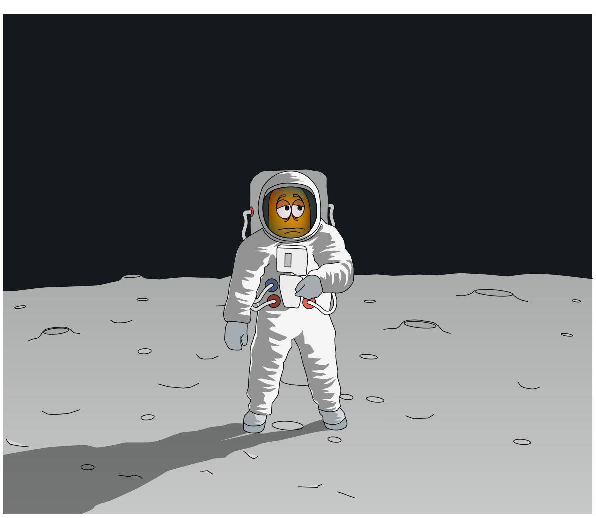
BACTERIAL PHYSIOLOGY

To boldly go where no cell has gone before

> "bacteria use non-nutritious attractants to promote the expansion of their populations into unoccupied territories"

Bacteria use chemotaxis to move towards or away from chemical attractants or repellents, respectively. Chemotaxis is thought to enable bacteria to move towards nutrients or away from danger. Now, Cremer, Honda et al. report an alternative physiological role for chemotaxis in which bacteria use non-nutritious attractants to promote the expansion of their populations into unoccupied territories. In a related study, Liu, Cremer et al. show that there is an optimal expansion speed when colonizing new territories, dependent on its size.

Chemical gradients are not only established by the environment, but are also shaped by bacteria consuming attractants. Cremer, Honda et al. investigated how the expansion speed of a colony of *Escherichia coli* on an agar plate depends on cell growth. The authors found that growth rate was largely determined by the carbon source and that expansion speed was dependent on the growth rate. Unexpectedly, in the presence of non-nutritious attractants, which do not affect the growth rate, expansion was faster, even if the primary carbon source was also an attractant. This contrasts with the view that chemotaxis is initiated by a shortage of nutrients.



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Next, the authors investigated the origin of the positive growth–expansion relationship and measured swimming speeds of individual cells, and found that swimming characteristics are independent of growth rate and that the positive growth–expansion relationship was likely to be dependent on collective population dynamics. The authors determined that an abundant primary carbon source supplemented with low amounts of an attractant is the minimal requirement for the behaviour. The authors modelled the growth–expansion relationship and, guided by experimental data, they suggest that non-nutritious attractants increase the number of cells that have access to the nutrients, allowing the population to grow faster. The attractant functions as a navigation 'guide', providing direction for bacterial cells to expand along self-generated attractant gradients into unoccupied territories. Remarkably, this diversification strategy provides bacterial communities with 'foresight' to expand into new territories before they encounter starvation conditions.

In this navigated expansion process, faster expansion leads to faster population growth, suggesting that faster expansion is always beneficial. However, bacterial populations are rarely clonal and competition between different strains leads to different scenarios. Liu, Cremer et al. used evolution experiments to understand the requirements for habitats of different sizes. The authors inoculated the centre of an agar plate with a population of *E. coli* cells, allowed it to expand, and then picked bacteria that had reached one of five fixed distances and seeded them on a new plate, where they expanded. This process was repeated 50 times, with samples always taken at the same positions relative to the centre.

Next, the authors evaluated the growth and expansion characteristics of the bacteria collected from the different cycles and positions. Interestingly, as cycles progressed, populations picked at sites furthest from the inoculation site always expanded quickly, whereas populations picked at closer sites always expanded more slowly.

In competition experiments, in which populations of bacteria with a range of expansion speeds (and with the same growth rate) were seeded at the same position, the different populations occupied different regions of the plate: slower populations deposited their offspring behind the front more rapidly, and dominated the interior of the plate, whereas faster populations deposited their offspring more slowly, and dominated the periphery.

Using simulations and modelling, the authors discovered a rule that predicts which population is fittest at any given distance from the inoculation site. Contrary to the notion that faster colonization provides the best advantage, the analysis showed that colonizing too quickly can leave the population susceptible to invasion by competitors, which could be applicable to pioneering populations across many territories.

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ORIGINAL ARTICLES Cremer, J. et al. Chemotaxis as a navigation strategy to boost range expansion. *Nature* https://doi.org/10.1038/s41586-019-1733-y (2019) | Liu, W. et al. An evolutionarily stable strategy to colonize spatially extended habitats. *Nature* https://doi.org/10.1038/s41586-019-1734-x (2019)