How a species stays relevant as it changes its world

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How complexity evolved in cells is a question as intriguing as it is difficult to explain. Though we cannot fully solve the puzzle, we can learn how species give themselves time to go from random to programmed development.

A new study published today in *PLOS ONE* reveals an optimal switching rate between forms of a species as it makes its environment less livable.

"If you're a bacterium in a beaker, just by the process of growing and dividing, you're changing the environment into one that no longer favors you," explains Eric Libby, an SFI Omidyar Fellow who specializes in mathematical microbial evolution. "You then have two options. One, go extinct. Two, throw off a mutant that's adapted to the new environment."

To see how a species adjusts to the conditions it creates, Libby and colleague Paul Rainey at the New Zealand Institute for Advanced Study looked to Pseudomonas fluorescens. The free-living bacterium has two forms: the smooth type proliferates in a broth, but by doing so uses up the oxygen. A single mutation produces the second wrinkly type, which makes a glue that sticks offspring together.

The resulting bacterial mat rises to the surface – the only place oxygen is available in a beaker choked by the smooth type. (Conversely, as the mat grows and provides stable access to oxygen, wrinkly types randomly produce smooth types.) Eventually the mat collapses, letting oxygen stream back into the broth.

Based on this simple life cycle, the researchers ran simulations where P. fluorescens drove the environment between two states, one favorable for either population type, to see at what switching rates the species flourished. The results surprised them.

"The best strategy is to produce the kind that's not good in the current environment about 10 percent of the time," says Libby. That rate is independent of environmental factors and is three orders of magnitude higher than the researchers expected. Further, letting some of both types survive through an environment switch also led to a surprising response: one organism will thrive, nearly driving the other to oblivion, then will suddenly collapse and die.

Libby reasons that these findings suggest that a simple relationship between organisms and environments could provide a possible route for the evolution of developmental programs from random mutation-driven change.

More information: Libby E, Rainey. "Eco-Evolutionary Feedback and the Tuning of Proto-Developmental Life Cycles." *PLoS ONE* (2013) 8(12): e82274. DOI: 10.1371/journal.pone.0082274

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