Mixed bacterial communities evolve to share resources, not compete

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New research shows how bacteria evolve to increase ecosystem functioning by recycling each other's waste. The study provides some of the first evidence for how interactions between species shape evolution when there is a diverse community.

Predicting how species and ecosystems will respond to new environments is an important task for biology. However, most studies of evolutionary adaptation have considered single species in isolation, despite the fact that all species live in diverse communities alongside many other species. Recent theories have suggested that interactions between species might have a profound effect on how each species evolves, but there has been little experimental support for these ideas.

The research, published May 15 in the online, open-access journal PLoS Biology, involved culturing five bacterial species in the laboratory, studying them both in isolation and mixed together in a community of all five species. Cultures were allowed to adapt to new conditions over seventy bacterial generations. The feeding habits of each species were then measured using chemical analyses; by comparing chemical resource use at the start and end of the experiment, it was possible to show how the resource use and waste production of each species had evolved.

The research team, from Imperial College London, found that bacteria that evolved in a mixed community with other species altered their feeding habits to share resources more effectively amongst themselves and to make use of each other's waste products in a cooperative manner.

In contrast, when grown alone, the same species evolved to use the same resources as each other, thereby competing and impairing each other's growth.

The changes in feeding habits led to a greatly improved functioning of the community of species as a whole. Communities that were reassembled with bacteria that previously evolved together were better, collectively, at breaking down resources than those reassembled with bacteria that had previously evolved in isolation. Together, the results show that the way in which species adapt is greatly altered by the presence of other species, and that co-evolution enhances the ecological functioning of groups of species.

"Our findings have wide implications for understanding how species respond to changing conditions," says Diane Lawrence, a PhD student in the Department of Life Sciences and Grantham Institute for Climate Change, and lead author of the study. "Because all species live together with many hundred other species present, the kind of phenomena observed here are likely to apply widely". For example, predicting how insects and plants will respond to climate change over the next hundred years—a timescale in generations similar to the one studied here for bacteria—will need interactions with other species to be measured and taken into account.

Similarly, the way in which the bacteria living in the human gut adapt to changes such as antibiotic treatments or a shift to a high-fibre diet is likely to depend on interactions among species. Tim Barraclough, who initiated the study, explains: "Engineering bacterial communities to improve human health requires greater understanding of the interactions among component species than we currently have. Our results provide a step in the right direction to developing that understanding."

The challenge now is to test whether species interactions are as important in shaping evolution in nature as they have been shown to be in the laboratory. This will require scaling up these experiments to include the hundreds or thousands of species found in real ecosystems.

More information: Lawrence D, Fiegna F, Behrends V, Bundy JG, Phillimore AB, et al. (2012) Species Interactions Alter Evolutionary Responses to a Novel Environment. *PLoS Biol* 10(5): e1001330. doi:10.1371/journal.pbio.1001330

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