Coexistence in microbial communities: Study challenges popular predictive rule

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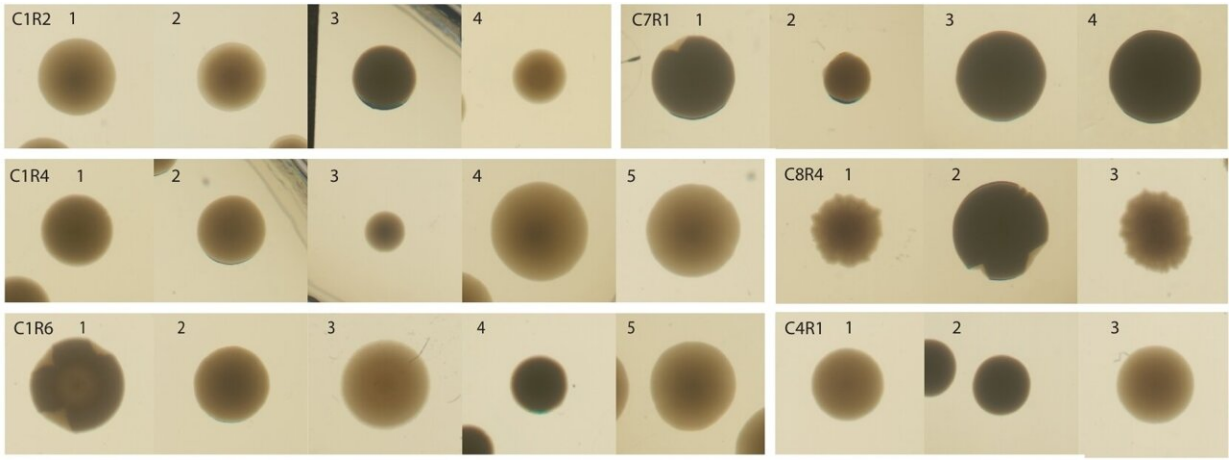

Images of 24 bacterial colonies from the studied microbial communities. Credit: Djordje Bajic

Microbial communities are widely used by biotechnology suppliers for processes like manufacturing biofuels and new foods, or helping crops grow better. To engineer successful communities, scientists need to predict whether microorganisms can live and work together. One popular predictive rule states that if a pair of microbes will coexist, they will also coexist in a bigger community of microbes. A study published in *Science* has now found that this simple rule will not always work.

Just like plants and animals, microorganisms live in complex ecological

communities consisting of multiple species that coexist with one another. These communities are found all over the planet, and they also play a growing and highly promising role in biotechnology. Microbial communities are being designed for producing biofuels and other essential products in biorefineries, to create new foods, or to help crops grow better. Thus, learning how to engineer these communities to improve the services they provide is a major goal in biotechnology.

One of the major roadblocks for engineering microbial communities is that not all microorganisms will coexist with one another. Even if we manage to design a microbial community with high potential, it is very likely that many of its members will go extinct. This is why scientists are trying to find ways to predict whether species will coexist with one another.

A simple rule

Researchers from University of Pennsylvania, Centro Nacional de Biotecnología of the Spanish National Research Council, Delft University of Technology and Yale University studied how to predict bacterial coexistence in complex communities.

In their paper, the authors have examined a popular hypothesis: that in order for multiple species (say A, B and C) to coexist as a community, every pair of species must also coexist with one another as an isolated pair, e.g. A must coexist with B, B must coexist with C, and C must coexist with A. This hypothesis has been gaining ground over the past few years, and it is very enticing, because if it were generally correct, it would offer a simple and practical way to predict coexistence in complex microbial communities.

To test this hypothesis, the authors decided to take apart twelve different microbial communities containing between three and ten species

coexisting together. They then compared every possible pair of microorganisms, and found that contrary to the above hypothesis, most pairs failed to coexist. In other words, the simple rule to predict coexistence will not always work, indicating that when it comes to coexistence, the whole is often more than the sum of its parts.

New predictive tools

The team's paper emphasizes that the important problem of predicting which microbes can live together is not yet solved, highlighting the need to build new predictive tools. Although this may be seen as bad news, it actually represents a huge leap forward by establishing that in microbial communities, the whole is much more than the sum of its parts. This will help us build new models that can ultimately help us engineer microbial communities.

"We are trying to understand the stunning diversity that we see in bacterial communities," says Djordje Bajić, Assistant Professor in Industrial Microbiology. "How can that many species manage to coexist within the same community?"

Understanding how bacteria coexist is important for a better understanding of our world, since microbial communities colonize almost every surface on our planet, Bajić explains, "They play roles in global element cycling and are essential for the health of our own gut microbiome. This study will definitely have an impact on our understanding of microbial communities and the microbiome. And it will also inform the building of models and technologies to design microbiomes and steer existing ones towards desired states in many applications: for example, in health, wastewater treatment, production of sustainable biopesticides and biofertilizers based on microbes."

You can think about this study as though you are at a party, where you

like many people, but you don't like many other people. The established idea is that you need to like everyone at the party in order to have a good time. This does not have to be the case, of course. You may just ignore the individuals you don't like, and choose to spend your night talking to other people. You may even participate in discussions with people you are less fond of, and still have a good time, as long as other people are also in these conversations.

More information: Chang-Yu Chang et al, Emergent coexistence in multispecies microbial communities, *Science* (2023). DOI: 10.1126/science.adg0727

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