Paradoxes in microbial economies

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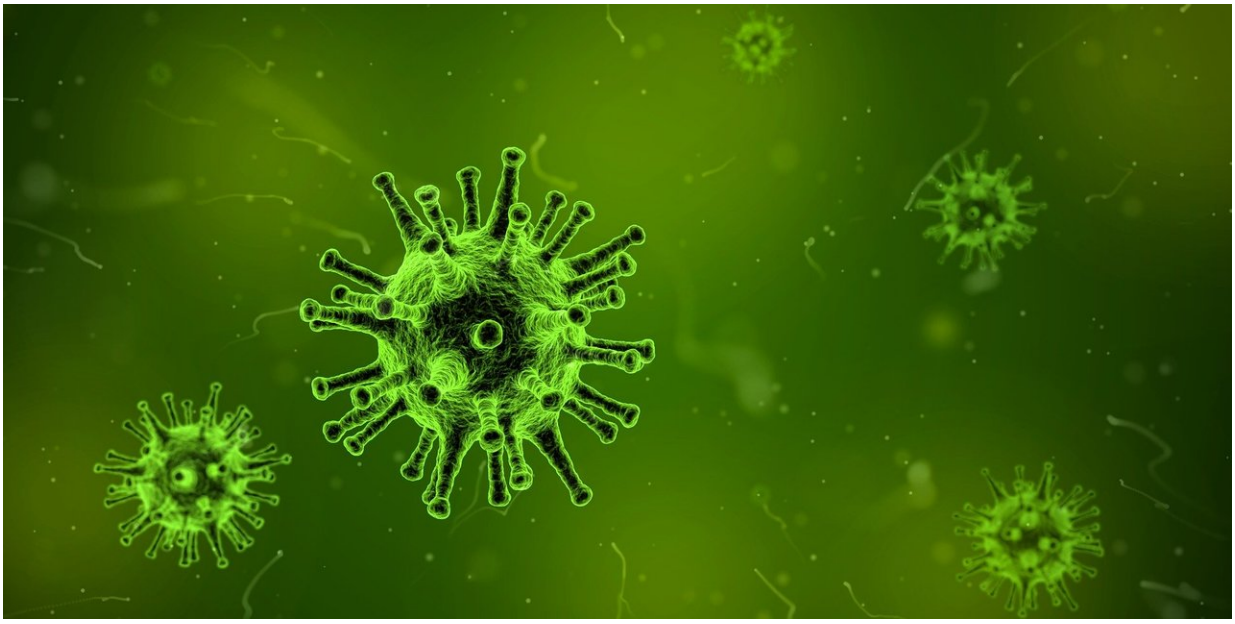

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Microbes can produce many of the metabolic resources they need to survive. But because they have permeable cell walls, those resources can leak out into the surrounding environment. Since microbes often live in communities with many other types of microbes, they can also take in the metabolic resources that other microbes have leaked. And, they can respond to their environments, shifting what and how much of some good they produce themselves. In a way, this exchange of goods is its own kind of economy—but it's one we humans don't understand well.

In a new paper in *Nature Communications*, three Santa Fe Institute researchers describe a trio of paradoxical dynamics that can arise in simple microbial economies. The paper looks at just one type of scenario: a self-sufficiency model where two types of microbes are producing goods that are valuable to both themselves and the others.

The first paradox is "the curse of increased efficiency." This occurs when Organism A is much more efficient at making a certain metabolite than Organism B. Organism B has no incentive, then, to produce that metabolite, so it stops. Consequently, Organism B can reproduce faster, meaning the more efficient producer, Organism A, eventually makes up a smaller size of the population.

The second paradox is "the curse of decreased inefficiency." Organisms can get better at making a good and the entire population then grows more slowly.

"This occurs because it leads to a lack of specialization whereby an organism produces both goods," says Eric Libby, Santa Fe Institute Omidyar Fellow and co-author on the study. "The community as a whole then becomes less efficient and grows more slowly."

The first two paradoxes assume that the two cell types make their own metabolic decisions independently. The third—the largely theoretical "curse of control"—assumes that one microbe can manipulate the other into following a particular strategy. The manipulator may initially increase its percentage of the overall population, but eventually experiences long-term losses. "Depending on the length of time of an association, it may be more beneficial to compete with another microbe than to exploit it," the authors write.

Understanding paradoxes in microbial economies could be important for approaching engineered microbial communities and better understanding

microbiomes. From an initial glance at these systems, it may seem obvious which microbes would benefit most from certain strategies of living in these metabolic economies. But looks, it turns out, can deceive.

More information: Yoav Kallus et al, Paradoxes in leaky microbial trade, *Nature Communications* (2017). DOI: 10.1038/s41467-017-01628-8

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