Cooperators can coexist with cheaters, as long as there is room to grow

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Microbes exhibit bewildering diversity even in relatively tight living quarters. But when a population is a mix of cooperators, microbes that share resources, and cheaters, those that selfishly take yet give nothing back, the natural outcome is perpetual war. A new model by a team of researchers from Princeton University in New Jersey and Ben-Gurion University in Israel reveals that even with never-ending battles, the exploiter and the exploited can survive, but only if they have room to expand and grow. The researchers present their findings at the 57th Annual Meeting of the Biophysical Society (BPS), held Feb. 2-6, 2013, in Philadelphia, Pa.

"In a fixed population, cells that share can't live together with cells that only take," said David Bruce Borenstein, a researcher at Princeton. "But if the population repeatedly expands and contracts then such 'cooperators' and 'cheaters' can coexist."

Our world and our bodies play host to a vast array of microbes. On our teeth alone, there are approximately a thousand different kinds of bacteria, all living in very close quarters. This is amazing, the researchers observe, because many of those species share resources with nearby neighbors, who might not be so cooperative or even related [1].

At the scale of cells, individuals cooperate mainly by exporting resources into the environment and letting them float away. "This is a deceptively complex process in which cells interact at long ranges, but compete only with nearby individuals," explained Borenstein. "Our models predict that, even when this exploitation prevents any possibility of peaceful coexistence, the exploiter and the exploited can survive across generations in what is basically a perpetual war." The researchers speculate that similar competition might occur between cancer cells and normal tissue.

Borenstein and his colleagues made their conclusions based on a computer model that considered two types of cells, cooperators and cheaters, and laid them out on a grid. Cooperators were given the ability, not uncommon in nature, to make a resource that speeds up growth in both kinds of cells. Producing this resource slowed down the growth of cooperators, because they have to divert some energy to resource production. This resource then spread out from the cooperator by diffusion, so that the cells closest to a producer have the greatest resource access. The model revealed that the producers tended to cluster, meaning that being a producer gave you greater access to resources. It also meant that even though cheaters are avoiding the cost of production, they pay for it with reduced resource access.

Within these basic constraints it was found that when the two populations must compete directly for survival, no coexistence is possible. "One type always wins out," observed Borenstein. However, when the two populations can grow into empty space, the researchers found a strange and paradoxical interaction: cheaters may be outcompeting cooperators locally, even as cooperators grow better overall. These complex interactions may play an important role in the maintenance of diverse microbial communities, like those seen in the mouth.

"To our astonishment, we found that while cheaters can exploit cooperators, cooperators can isolate cheaters, just from cooperation and growth," concludes Borenstein. "As a result, the community can persist in a sort of perpetual race from which a winner need not emerge."

More information: [1] J. M. ten Cate. "Biofilms, a new approach to the microbiology of dental plaque." Odontolgy 2006(94):1-9.

Presentation #2530-Pos, "Diffusion of public goods prevents coexistence of cooperators and cheaters in a stochastic competition model," will take place at 1:45 p.m. on Tuesday, Feb. 5, 2013, in the Pennsylvania Convention Center, Hall C. ABSTRACT: tinyurl.com/ba46sdb

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