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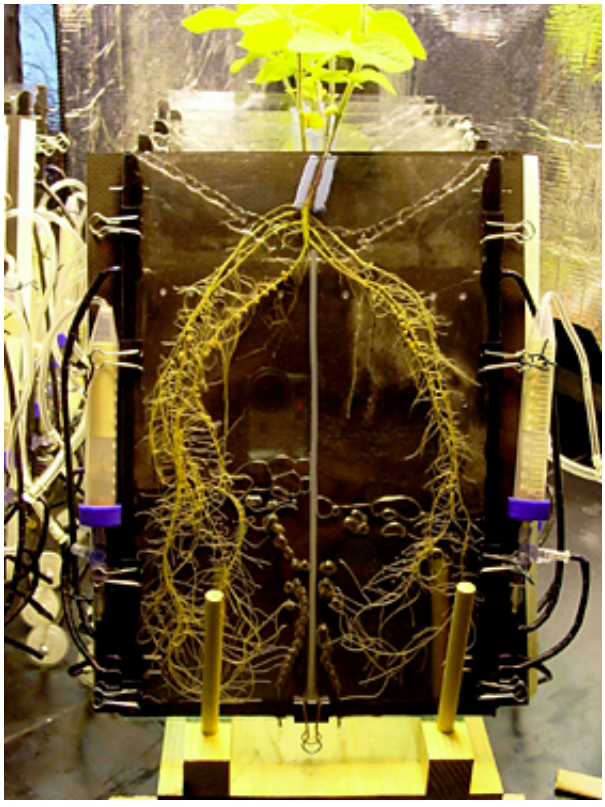
The Dark Side of Cooperation

In a world that's red in tooth and claw, cooperation between species is about as cuddly as nature gets. Although each party apparently reaps greater benefits from teaming up, some of these arrangements aren't all smiles and handshakes. A new study shows that soybean plants can apply sanctions against symbiotic bacteria when the bugs don't deliver their fair share of nitrogen.



Cheaters never prosper. Some plants cut off the oxygen supply to symbiotic bacteria on their roots when the bacteria shirk their

Legumes such as soybeans prosper from the services of soil bacteria called rhizobia. Dwelling in nodules on the plant's roots, they convert nitrogen into a form that plants can use. In turn, the plant offers nutrients and regulates oxygen needed for rhizobia to grow and reproduce. It sounds like a win-win situation, but often several strains of rhizobia provide nitrogen for the plant--and compete with one another. Rhizobia investing their energy and resources on their own growth and reproduction instead of nitrogen conversion would seemingly come out ahead, so why do the rhizobia keep putting out?

Evolutionary ecologist Toby Kiers and her colleagues at the University of California, Davis, suspected that the plants were somehow penalizing bacteria that cheat by fixing little or no nitrogen. To test that hypothesis, the researchers simulated bacterial job-shirking by replacing the air surrounding selected nodules with a nitrogen-free mixture of argon and oxygen. This reduced bacterial nitrogen conversion to just 1% of normal. The plants responded by cutting oxygen flow to the treated nodules, which diminished the

nitrogen-producing duties. As a result the cheating bacteria grow more slowly (right).
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"cheating" rhizobia's ability to reproduce by about 50%, while populations on untreated nodules kept growing over the several weeks of the experiments, the team reports in the 4 September issue of *Nature*.

The work offers a new perspective on cooperation, says behavioral ecologist Bernard Crespi of Simon Fraser University in Burnaby, British Columbia. It portrays symbiotic relationships "not as a simple, friendly interaction where every party happily gains, but as trade with a dark side: 'Provide the resource I require and I will reciprocate; do not, and suffer dire consequences.' "

--NOREEN PARKS

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