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Plants and fungi recognize generous trading partners

Rewards for rewards stabilize underground biological market

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ENLARGE

TRADING ROOTS

Threads of mycorrhizal fungi (white) connect to the roots of their plant hosts. Researchers have found that both sides have a say in the terms of this symbiotic relationship.
Courtesy of Yoshihiro Kobae

One of the biggest underground markets on the planet — nutrient trading between plant roots and fungi — turns out to run on a system of reciprocal rewards for good suppliers and less business for bad ones.

"It may have taken 450 million years to evolve," says Toby Kiers of VU University Amsterdam, "but unlike most human markets, here we have an example in which cheaters actually get punished and the good guys get rewarded."

Most land plants participate in this exchange, as threads of specialized fungi wind into plant root tissue and form structures called arbuscular mycorrhizae. About 4 percent to 20 percent of the carbon compounds a plant produces from capturing the energy of sunlight flows into the fungus. In the other direction, minerals and other useful compounds flow from the fungus into the plant.

Other cross-species mutualisms have turned out to have a lopsided power balance in which one partner, often a plant, can kill a misbehaving helper. In the arbuscular mycorrhizal system though, plant roots can detect which fungus threads are providing an abundance of a mineral and in turn reward them with extra nutrients in the form of plant-produced carbon. And the fungi also can detect and preferentially reward a good supplier and shun a slacker, Kiers and her colleagues report in the Aug. 12 *Science*.

That's a different picture from other natural exchanges studied so far, says Jason Hoeksema of the University of Mississippi, who also studies plant-fungal interactions. "One exciting thing about these data is that they support the idea of a mycorrhizal market with competition and variation in offered prices on both sides, with reciprocal responses by choosy partners."

Also, Hoeksema adds, "the authors used some really innovative techniques to get these answers."

Initially, one collaborator called the project "impossible," Kiers recalls, because the plan called for tracking nutrient flows on very small scales. Fungal strands grow over roots in a spaghetti-like tangle of mingled species. Whether a plant could detect and reward an outstanding fungus while snubbing some fungal Scrooge just a thread or two away has been a matter of considerable debate.

Researchers first looked at whether a plant in the bean family, *Medicago truncatula*, could distinguish between different closely related fungi known to provide different amounts of phosphorus to partners. To see, researchers let the fungi wind intimately around the plant roots and then labeled the carbon flowing through the fungal-plant snarl with a heavier than normal isotope. Centrifuging RNA molecules from the fungi revealed where more of the heavy carbon had gone. The plant had indeed given more carbon to the more generous fungus species.

To see if fungi would respond likewise, researchers set up lab dishes with compartments that forced some plant roots to cheat by restricting the amount of carbon they passed on. Other roots acted as good-guy partners for the fungi. "I think we were all rooting for the underdog, hoping the world has thus far underestimated the bargaining power of fungi," Kiers says. And yes, the fungi did pass along more of their phosphorus to the generous suppliers.

"Absolutely wonderful work," comments Ronald Noë of the University of Strasbourg, France, who studies biological markets. Major steps in evolution often depended on the rise of ways to stabilize cooperation between organisms, he points out. "You wouldn't exist without mutualisms, and you would have little to eat without the arbuscular mycorrhizal fungi."

SUGGESTED READING :

S. Milius. Nature's recourse. Science News, Vol. 178, July 31, 2010, p. 22. Available online:

CITATIONS & REFERENCES :

E. Toby Kiers et al. Reciprocal rewards stabilize cooperation in the mycorrhizal symbiosis. Science, Vol. 333, August 12, 2011, p. 880. doi: 10.1126/science.1208473

E. Toby Kiers et al. Reciprocal rewards stabilize cooperation in the mycorrhizal symbiosis. Science, Vol. 333, August 12, 2011, p. 880. doi: 10.1126/science.1208473