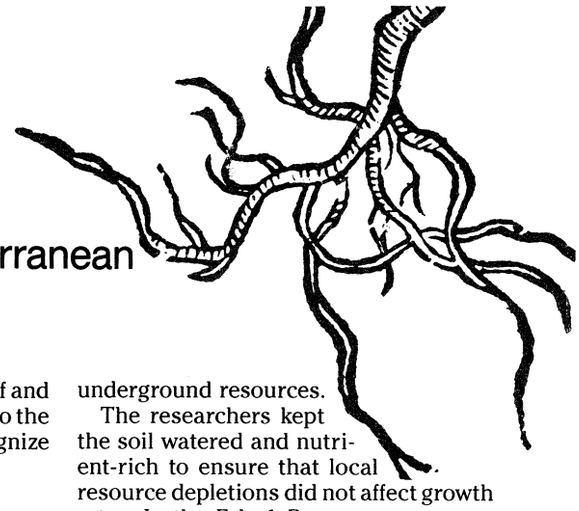
# Root Words

## Scientists strengthen the case for subterranean signals among plants



By RICK WEISS

Plant communities may be abuzz with conversations no one can hear, dispatching chemical messages from their roots. For those wishing to eavesdrop on these buried dialogues, standard listening equipment proves useless. But two biologists have now devised a unique apparatus for tapping underground communications, and have documented intriguing ways in which plants use silent signals to stake out their territory or recognize their neighbors.

Plant ecologists have long recognized that some plant species seem to prefer a clumped existence while others space themselves with near-military precision. And when two or more species share the same piece of land, negotiating a delicate ecological balance, remarkably complex distribution patterns can evolve. Biologists generally attribute these patterns to differences in various plants' competitive abilities as they vie for nutrients, light and water. But new findings offer some of the best evidence yet that plant communities also attain ecological equilibrium by stimulating and inhibiting neighboring plants via chemicals exuded from their roots — a phenomenon known as allelopathy.

Moreover, the work provides strong indications that some plants can differentiate between their own roots and those of their same-species neighbors. This raises the tantalizing possibility that some plants distinguish between self and nonself in a process somewhat akin to the way animal immune systems recognize foreign substances.

For centuries, naturalists have suspected that the roots of some plants secrete compounds that affect the growth of surrounding plants. In 1828, French zoologist and botanist Jean Louis Berlandier speculated that root-released substances accounted for the remarkably regular distribution of certain desert plants in the U.S. Southwest. Until now, however, scientific evidence of such communication has remained elusive.

Bruce E. Mahall and Ragan M. Callaway of the University of California, Santa Barbara, figured the best way to see what's really going on underground is to watch live roots as they grow. The two biologists devised a system of interlocking, partially transparent growth boxes that allowed them to observe interactions between the roots of two desert shrubs: the common creosote bush *Larrea tridentata* and the so-called burro weed *Ambrosia dumosa*.

By measuring growth rates of the roots of "test" plants as they extended downward and approached the roots of "target" plants, Mahall and Callaway found that the two species have different ways of influencing each other as they seek underground resources.

The researchers kept the soil watered and nutrient-rich to ensure that local resource depletions did not affect growth rates. In the Feb. 1 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, they report that *Ambrosia* test roots slowed their growth as they neared target *Larrea* roots. This unprecedented observation suggests that *Larrea* roots produce a diffusible growth inhibitor, they say. Inhibition started at a distance of a few centimeters; at closer range, the test roots stopped growing altogether.

The researchers have since discovered that they can block *Larrea*'s growth inhibition by adding to the soil some activated charcoal, which absorbs and inactivates organic compounds. That unpublished finding strengthens the argument that growth inhibition is triggered by a diffusible, biological compound, they and others maintain.

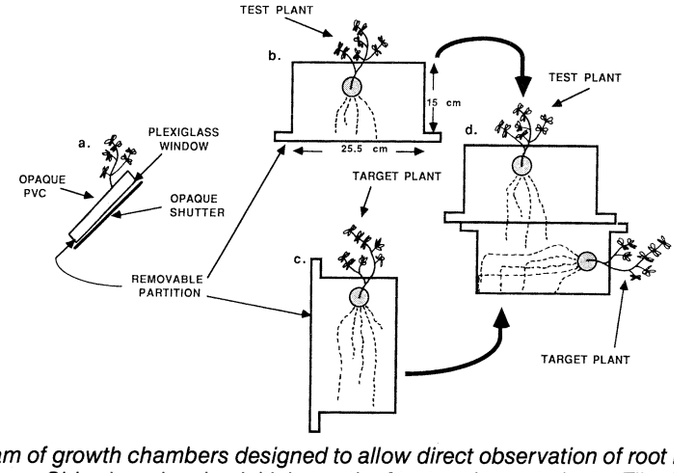
*Larrea* test roots, in contrast, appear unaffected as they approach *Ambrosia* target roots, indicating that *Ambrosia* roots lack such inhibitors.

But actively growing *Ambrosia* roots may have their own strategy for avoiding competition as they near roots of the same species. *Ambrosia* roots stop growing when they touch the roots of other *Ambrosia* plants, hinting at the presence of a growth-inhibition mechanism that requires direct contact. Such a mechanism would allow a plant to put its energy into roots far away from competing tendrils.

Interestingly, Mahall and Callaway saw contact inhibition only among *Ambrosia* roots from different plants; when root tips from the same *Ambrosia* plant came in contact with each other, no inhibition occurred. That finding, they say, "suggests that this detection mechanism involves a capability of self-nonself recognition."

The results hearten those who have sought good evidence for root communication, says Frank Einhellig, an allelochemist at the University of South Dakota in Vermillion. "I'm not familiar with any other system that allows real-time observation of root interactions in soil," he says.

Botanist Cornelius Muller, who in the 1960s became one of the first U.S. scien-




Mahall

*Diagram of growth chambers designed to allow direct observation of root interactions. a: Side view showing initial growth of test and target plants. Tilted orientation insures roots grow against removable partition. b and c: Front views of test and target plant chambers. d: Front view of interlocked chambers after partitions have been removed.*

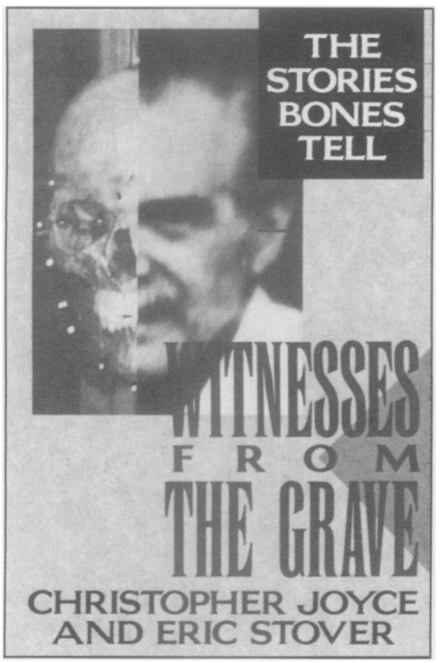
tists to explore allelopathic phenomena, calls the new work "excellent," noting that many biologists have argued about the theory of plant allelopathy but few have actually designed ways of documenting it. The growth-box experiments "actually test the idea, and the idea came through beautifully," says Muller, now a professor emeritus at the University of California, Santa Barbara.

Mahall says he has yet to identify *Larrea*'s inhibitory compound or determine how long it remains active in the soil. The mechanism by which *Ambrosia* responds to close contact also remains a mystery, as does the means by which individual plants differentiate between self and other.

However, he and Callaway assert in their report, "the fact that we found a form of root communication in each of the two species we investigated suggests the paucity of information in the literature does not reflect the occurrence of such phenomena in the field."

Mahall and Callaway say their findings do not invalidate long-standing observations that plant distribution patterns reflect competition for limited resources. However, they add, scientists should also recognize that a subterranean war of words—in the form of chemical signals—plays a role in the processes by which plant communities constantly redraw their common borders. □



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