# Are plants intelligent? It depends on the definition

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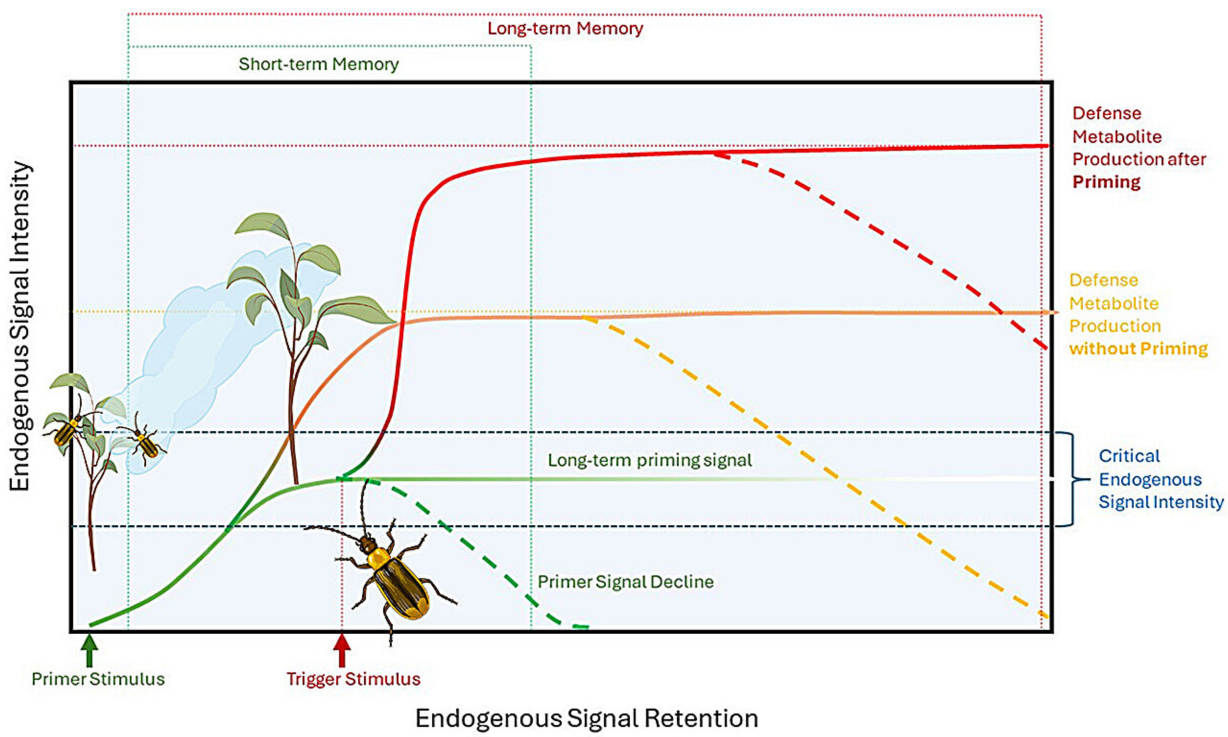


The predictive value of environmental information to the plant defending against herbivory. The reliability of environmental information lies in the intensity of the primer stimulus, the plant's sensitivity to the primer stimulus, and the environmental noise obstructing information transfer. Plants should evolve stronger priming responses (endogenous signaling) to more reliable environmental cues (A), while reducing the threshold for direct induction of defense-related metabolic changes (B). The threshold is determined by the zone of critical endogenous signal intensity, within which a trigger stimulus will induce stronger and faster responses and above which resistance is directly induced. Credit: *Plant Signaling & Behavior* (2024). DOI:

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Goldenrod can perceive other plants nearby without ever touching them, by sensing far-red light ratios reflected off leaves. When goldenrod is eaten by herbivores, it adapts its response based on whether or not another plant is nearby.

Is this kind of flexible, real-time, adaptive response a sign of intelligence in plants?

The question is not easy to answer, but Andre Kessler, a chemical ecologist, makes an argument for plant intelligence in a recent paper in the journal *Plant Signaling and Behavior*.

"There are more than 70 definitions that are published for intelligence and there is no agreement on what it is, even within a given field," said Kessler, professor in the Department of Ecology and Evolutionary Biology in the College of Agriculture and Life Sciences.

Many people believe that intelligence requires a central nervous system, with electrical signals acting as the medium for processing information. Some plant biologists equate plant vascular systems with central nervous systems, and propose that some kind of centralized entity in the plant allows them to process information and respond. But Kessler firmly disagrees with that idea.

"There is no good evidence for any of the homologies with the nervous system, even though we clearly see electrical signaling in plants, but the question is, how important is that signaling for a plant's ability to process environmental cues?" he said.

To make their argument for plant intelligence, Kessler and co-author Michael Mueller, a doctoral student in his lab, narrowed their definition down to the most basic elements: "The ability to solve problems, based on the information that you get from the environment, toward a particular goal," Kessler said.

As a case study, Kessler points to his earlier research investigating goldenrod and its responses when eaten by pests. When leaf beetle larvae eat goldenrod leaves, the plant emits a chemical that informs the insect that the plant is damaged and is a poor source of food. These airborne chemicals, called volatile organic compounds (VOCs), are also picked up by neighboring goldenrod plants, prompting them to produce their own defenses against the beetle larvae. In this way, goldenrod moves herbivores on to neighbors, and distributes damage.

In a 2022 paper in the journal *Plants*, Kessler and co-author Alexander Chautá, Ph.D., ran experiments to show that goldenrod can also perceive higher far-red light ratios reflected off leaves of neighboring plants. When neighbors are present and goldenrod is eaten by beetles, the plants invest more in tolerating the herbivore by growing faster, yet also start producing defensive compounds that help the plants fight off insect pests. When no neighbors are present, the plants don't resort to accelerated growth when eaten and the chemical responses to herbivores are markedly different, though they still tolerate quite high amounts of herbivory.

"This would fit our definition of intelligence," Kessler said. "Depending on the information it receives from the environment, the plant changes its standard behavior."

Neighboring goldenrod plants also exhibit intelligence when they perceive VOCs that signal the presence of a pest. "The volatile emission coming from a neighbor is predictive of future herbivory," Kessler said.

"They can use an environmental cue to predict a future situation, and then act on that."

Applying the concept of intelligence to plants can inspire fresh hypotheses about the mechanisms and functions of plant chemical communication, while also shifting people's thinking about what intelligence really means, Kessler said.

The latter idea is timely, as artificial intelligence is a current topic of interest. For example, he said, artificial intelligence doesn't solve problems toward a goal, at least not yet. "Artificial intelligence, by our definition of intelligence, is not even intelligent," he said. It is instead based on the patterns it identifies in information it can access.

An idea that interests Kessler came from mathematicians in the 1920s who proposed that perhaps plants functioned more like beehives. In this case, each cell operates like an individual bee, and the entire plant is analogous to a hive.

"What that means is the brain in the plant is the entire plant without the need of central coordination," Kessler said.

Instead of electrical signaling, there is chemical signaling throughout the superorganism. Studies by other researchers have shown that every plant cell has broad light spectrum perception and sensory molecules to detect very specific volatile compounds coming from neighboring plants.

"They can smell out their environment very precisely; every single cell can do it, as far as we know," he said. Cells might be specialized, but they also all perceive the same things, and they communicate via chemical signaling to trigger a collective response in growth or metabolism.

"That idea is very appealing to me," he said.

**More information:** André Kessler et al, Induced resistance to herbivory and the intelligent plant, *Plant Signaling & Behavior* (2024). DOI: 10.1080/15592324.2024.2345985

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