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PLANT SENSORY SYSTEMS AND ADAPTIVE GROWTH: A NEW FRAMEWORK FOR DECISION-MAKING IN PLANTS

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Abstract: Plants have traditionally been considered passive organisms, responding to environmental stimuli through simple reflexes. However, recent discoveries in plant neurobiology suggest the existence of more complex, information-processing capabilities. This study presents a novel theoretical and experimental framework proposing that plants possess decentralized sensory networks enabling environmental perception and decision-based adaptive growth. Experimental evidence from broomgrass plants demonstrates anticipatory growth adjustments in response to obstacles, implying a level of spatial awareness. These findings support the presence of signal integration and internal information processing in plants, akin to primitive neural systems. This new framework opens possibilities for understanding plant intelligence, inter-plant communication, and the design of bioinspired systems.

Main Text

Introduction

While plants lack a central nervous system, emerging data in plant electrophysiology and behavior reveal advanced adaptive mechanisms. Plants like Dionaea muscipula generate electrical impulses in response to mechanical stimuli, indicating functional analogs to neural action potentials. These signal networks are key to understanding non-animal information processing.

Evidence from Ion Channels and Signal Transmission

Root and leaf cells of plants contain ion channels regulating calcium, potassium, and sodium flow. These ion fluxes generate electrical potentials critical for intra-plant signaling. Rapid responses in Venus flytrap and Mimosa pudica indicate signal specificity and system-wide integration.


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Environmental Sensitivity and Tropic Behavior

Tropisms demonstrate directed responses:
- Phototropism aligns growth with light gradients;
- Gravitropism manages orientation via statolith-mediated detection;
- Thigmotropism enables structural interaction and avoidance.

These responses reveal a coordinated capacity to perceive and respond to stimuli spatially and temporally.

Variable Growth Strategy: A Theoretical Proposal

We propose the Variable Growth Strategy Theory, positing that plants assess environmental constraints and adjust morphology proactively. Unlike reflexive behavior, this suggests conditional decision-making based on signal analysis.

Experimental Approach

In a controlled experiment, broomgrass was grown near a fixed obstacle. Over 14 days, the plant's growth trajectory deviated, suggesting the plant 'anticipated' the obstruction. The curvature data (10° on day 3, 13.125° on day 11) supports the notion of non-contact spatial

sensing.

Interpretation and Mechanistic Hypothesis

The plant's adjustment implies a distributed sensing network, potentially integrating light gradient shifts, humidity, mechanical feedback, and internal hormonal signaling. Such integration resembles lateral line perception in blind cavefish and supports the notion of decentralized cognition in plants.

Scientific Significance and Implications

This framework supports the notion that plants are capable of primitive cognition and decision-making. These findings contribute to plant neurobiology and may inspire bioinspired sensor systems and eco-responsive robotics.

Future Directions

- Mapping action potentials and ion fluxes in root and shoot tissues;
- Identifying specialized sensor-like structures;
- Exploring electric signaling-based plant-to-plant communication;
- Monitoring signal dynamics via nanosensors.

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