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The Secrets of Plant Memory: How Plants Remember and Learn from Their Experiences

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Introduction

Plants may not have brains, but they are not mindless. They can sense and respond to their environment, and even remember and learn from their past experiences. But how do plants store and recall information without neurons and synapses? And what kind of information do they remember? This revelation challenges our understanding of plant intelligence and opens up new avenues of research into the intricate world of plant cognition.

What is plant memory?

The concept of plant memory refers to the ability of plants to retain information from past experiences and use it to respond appropriately to future stimuli. Just like animals, plants have developed mechanisms to store and recall information, enabling them to adapt and thrive in their environments. Plant memory may not resemble human memory in its complexity, it exhibits remarkable adaptive behaviors that contribute to their survival and growth. For example, many plants sense and remember prolonged cold during winter to ensure that they flower in spring. Another example of plant memory is the Venus flytrap, which can remember when its tiny hairs are touched by an insect. Further, some plants raise their leaves synchronously with the rising of the sun, a phenomenon known as solar tracking. This behavior suggests that plants possess an internal clock that allows them to anticipate and prepare for environmental changes.

This is due to "epigenetic memory" that occurs by modifying specialized proteins called histones, which are important for packaging and indexing DNA in the cell. By changing the shape and accessibility of DNA, histones can turn genes on or off, affecting the expression of traits (Galviz et al. 2020). These epigenetic changes do not alter the DNA sequence, but affect how genes are turned on or off during stress conditions. Epigenetic memory can help plants adapt to changing or recurring conditions, such as cold, drought, heat, or pathogens. Epigenetic memory

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can be established by different mechanisms, such as DNA methylation, histone modifications, and small RNAs.

Fig. 1: Touch-me-not plant (*Mimosa pudica*) in action

These mechanisms can influence the structure and function of chromatin, which is the complex of DNA and proteins that forms chromosomes. Plant memory can also involve changes in chemical signals, such as hormones and sugars, that regulate plant growth and development. Further, Studies have shown that plant memory relies on various molecular and physiological mechanisms. Hormones, such as abscisic acid (ABA) and jasmonic acid (JA), play crucial roles in mediating plant transcriptional memory and priming responses to recurring environmental conditions (Hilker and Schmülling 2019). Few studies have also shown that calcium waves have been proposed as a main mechanism for learning, storing, and recalling information in plants (Ripoll et al. 2009).

Research has demonstrated that plants exhibit different forms of memory, including sensory, short-term, and long-term memory. Sensory memory allows plants to perceive and respond to immediate stimuli, while short-term memory enables them to retain information for a short period. Long-term memory, on the other hand, involves the storage and retrieval of information over an extended period, potentially influencing future behaviors and responses.

Why is plant memory important?

Plant memory is important for plant survival and adaptation. By remembering previous stimuli, plants can adjust their responses to future conditions, making them more efficient and effective. For example, some plants can remember the direction and timing of sunlight, and adjust their leaf orientation accordingly to optimize photosynthesis. Other plants can remember herbivore attacks, and increase their production of defensive chemicals or attract predators of the herbivores (Lev-Yadun 2021). Plant memory can also help plants cope with unpredictable and variable environments, where stress factors may recur or change in intensity. By remembering past stress events, plants can prepare themselves for future challenges, either by strengthening their defenses or by avoiding them. For example, some plants can remember heat stress by

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producing heat shock proteins, which protect them from protein damage. Other plants can remember salt stress by reducing their root growth and increasing their shoot growth, avoiding salt accumulation in the soil.

How do we study plant memory?

Studying plant memory is not easy, as it requires careful experimental design and control. One challenge is to distinguish between memory and acclimation, which are both adaptive responses to environmental changes. Memory implies that the plant retains information after the stimulus is removed, while acclimation implies that the plant adjusts its response only while the stimulus is present. To test for memory, researchers need to expose plants to different stimuli at different times and measure their responses after a recovery period.

Another challenge is to identify the molecular mechanisms underlying plant memory, which may vary depending on the type of stimulus, the duration of exposure, and the plant species. Researchers use various tools and techniques to investigate plant memory at different levels of organization, from genes to cells to organs to whole plants. Some examples are molecular biology, biochemistry, physiology, microscopy, electrophysiology, genomics, phenomics, and high-throughput sequencing.

What are the implications of plant memory?

Plant memory has implications for both basic and applied research. The implications of plant memory extend beyond their own survival. Understanding how plants remember and learn can have practical applications in agriculture, horticulture, and environmental conservation. By understanding how plants remember and learn from their experiences, we can gain insights into the evolution and diversity of plant life. Scientists are also aiming to enhance crop yields, optimize resource allocation, and develop strategies to protect plants from stressors like drought and pests.

We can also discover new ways to improve plant performance and productivity under changing climate conditions. For example, we can manipulate plant memory by applying chemical or physical stimuli that induce desirable traits or behaviors in plants. We can also select or breed plants that have better memory capacity or quality for specific environments.

Plant memory also has implications for our perception of plants as living beings. By recognizing that plants have memory and learning abilities similar to animals, we may appreciate them more as complex and intelligent organisms that deserve our respect and care. We may also learn from them as models of resilience and adaptation in a changing world. Furthermore, the study of plant memory challenges our perception of intelligence and cognition in the natural world. While plants lack a centralized nervous system like animals, they demonstrate adaptive behaviors that parallel some of the basic functions of memory observed in animals. By studying

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plant memory, scientists hope to gain insights into the evolution of memory systems and shed light on the fundamental principles that govern learning and memory across different organisms.

Application of plant memory in agriculture for crop improvement

One of the applications of plant memory in agriculture is to use seed priming as a technique to induce immune memory in crops. Seed priming is a process where seeds are exposed to mild stress or chemical agents before sowing, which can improve their germination, growth, and resistance to pathogens. Seed priming can also modulate the epigenetic status of the seeds, which can affect the expression of genes involved in stress responses and plant development. Seed priming can be used to enhance the performance of crops in different agro-climatic conditions and increase their yield and quality.

Another application of plant memory in agriculture is to use epigenetic engineering as a tool to modify the stress memory of crops. Epigenetic engineering is a method where the epigenetic marks of plants, such as DNA methylation, histone modifications, and small RNAs, are manipulated to alter the expression of target genes. Epigenetic engineering can be used to create stable and heritable changes in the stress memory of crops, which can improve their adaptation and tolerance to various abiotic stresses. Epigenetic engineering can also be used to introduce novel traits and enhance the nutritional value of crops.

References

Galviz YC, Ribeiro RV, Souza GM (2020) Yes, plants do have memory. Theoretical and experimental plant physiology 32 (3):195-202

Hilker M, Schmülling T (2019) Stress priming, memory, and signalling in plants. vol 42. Wiley Online Library,

Lev-Yadun S (2021) Avoiding rather than resisting herbivore attacks is often the first line of plant defence. Biological Journal of the Linnean Society 134 (4):775-802

Ripoll C, Sceller LL, Verdus M-C, Norris V, Tafforeau M, Thellier M (2009) Memorization of abiotic stimuli in plants: a complex role for calcium. Plant-Environment Interactions: From Sensory Plant Biology to Active Plant Behavior:267-283

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