

## Vernalization: The Memory of Winter

Bolle Sowmya<sup>1</sup>, Anugula Sowjanya<sup>2</sup>,

<sup>1</sup>Teaching Associate, Dr.Ganta Gopal Reddy Horticulture Polytechnic, Gaddipally, Telangana

<sup>2</sup>M.Sc Floriculture and Landscape Architecture, SKLTGHU, Mulugu, Telangana

Corresponding Author : sowmyabolle7@gmail.com

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### Introduction:

#### Every Leaf Is a Living Wonder

Every plant that thrives in the lap of nature is a miracle. What we see outside the branches and leaves is only the trailer. The real thing is happening inside, in the hidden atomic world within the cells. Plants have no brain and no nerves. Yet, how do they behave so intelligently sometimes even more cleverly than humans?

Do plants remember hardships they faced last year or even last month? This question challenges human intelligence itself. The tree we see every day appears to stand silently. But behind that silence lies a complex calculation. Plants have no legs they cannot run away or hide. Still, whenever the environment changes, they alter their body, their functioning, and their pace of growth. Behind this ability to adapt lies something like “memory.” What is the secret behind it?

#### How Plants Endure Hardships

When we feel cold, we move to a warmer place. When it’s hot, we seek shade. But how does a tree, rooted in one place, survive scorching heat, freezing cold, floods, and droughts?

More importantly, how does a plant remember the cold it experienced last December and decide to flower at the right time when spring arrives? How does it know, “Winter has passed, now it’s time”?

Scientists call this process **vernalization** the plant’s ability to store the experience of winter and use it to trigger flowering when warmth returns. This is not random. Researchers at the University of York have recently proven that plants possess a precise, digital-like memory system that records seasonal experiences.

#### The Magic Inside Cells

In humans, memory is formed through connections between neurons in the brain. In plants, however, memory exists as chemical marks. This is called epigenetics, or the science of hereditary changes without altering DNA. The term may sound complex, but the idea is simple

Without changing the DNA itself, cells modify how genes behave by placing tiny chemical “tags” on them. Just like sticking a marker on an important page in a book, plants place chemical marks on their genes.

When cold increases, certain proteins inside the cell nucleus cluster together and signal:

“It’s cold now save energy, don’t flower.” What’s fascinating is that even when the cold reduces, these protein clusters don’t immediately disappear. They remain, safely stored like data saved on a computer’s hard drive. Thus, plant memory persists as subtle chemical marks and protein structures inside cells.

## A New Eye Through the Microscope

The mystery of protein memory in plants was revealed using an advanced microscope called “**Slimver**”. Ordinary microscopes only show the surface of cells. Slimver, however, allows scientists to see live activity inside cells how proteins move, how they cluster almost like a real-time video.

Scientists conducted these experiments on a small model plant. Using Slimver, they observed that as soon as cold increased, certain proteins began clustering together. This clustering is the very first step in forming plant memory. In short, a plant’s memory of cold begins at the level of protein groups.

### What is Slimver?

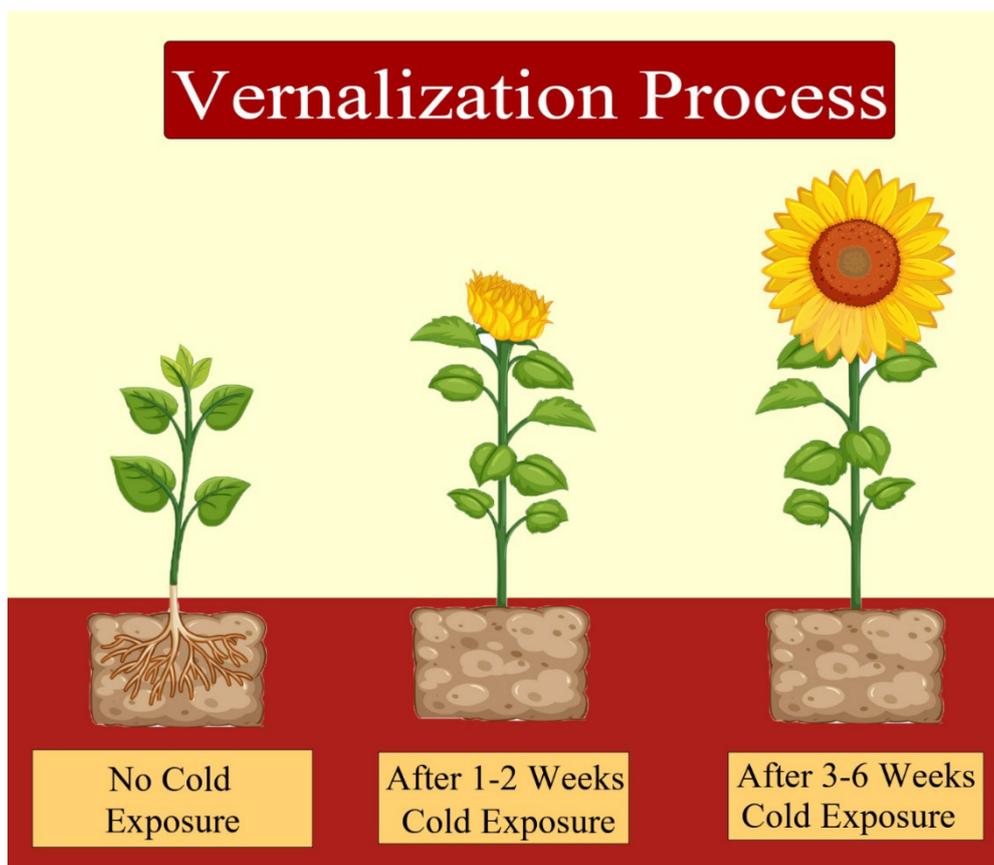
Slimver refers to a high-resolution, advanced live-cell imaging microscope used in modern biological research.

It is not a common household microscope, but a state-of-the-art scientific imaging system that allows scientists to see what is happening inside living cells in real time.

### Why is Slimver important in this research?

Using Slimver, scientists:

- discovered how plants store “memory” as protein clusters
- observed how plants remove unwanted protein buildup
- learned the cellular cleaning mechanism that keeps plant cells healthy



## **The Green Diary: Memory Cleaning in Plants**

We often assume plants have no brain. Yet, the solution to one of the human brain's biggest problems may lie within plants.

The human brain is like a supercomputer with billions of neurons transmitting information. As we age, a sticky protein called amyloid accumulates between neurons, blocking communication much like algae clogging a water pipe. This leads to memory loss and Alzheimer's disease. In a way, it is like rust forming in the brain.

Plants, remarkably, handle protein buildup far better. During winter, they form protein clusters to survive cold like wearing layers of clothing. But when spring arrives, they carefully dismantle these clusters. Plant cells continuously recycle accumulated protein waste with extraordinary efficiency.

If we can understand this cellular "cleaning technology" using Slimver, scientists hope to develop medicines that could dissolve the "rust" of Alzheimer's in the human brain. One day, lessons from plant cells may help heal human memory.

### **When Seasons Go Out of Balance**

Global warming has disrupted seasonal cycles. Winters arrive early or late, don't last long enough, and behave unpredictably. Plants too become confused when to flower, when to bear fruit? A single mistake in timing can destroy an entire crop.

If plant memory falters, food security itself is threatened. That's why research from the University of York is so crucial. Scientists are now studying how plants modify their memory to adapt to changing climates. They are comparing protein systems in heat-tolerant plants with those in cold-tolerant ones.

Simply put, they are exploring ways to teach one plant's resilience to another paving the way for crops that can withstand any climate.

### **From Fields to the Future: Robotic Plants**

A plant is not just leaves it is a living machine. Scientists are now trying to copy its blueprint to create artificial plants. Understanding plant memory is key to programming plants to respond the way we want.

In polluted cities, plants could be programmed to absorb toxins nonstop. On Mars, such plants could survive extreme cold and produce oxygen. In cities, they could grow on concrete walls as smart plants that purify air.

According to scientists, there is almost nothing plants cannot be adapted to do.

### **A Library Inside Every Leaf**

Climate change has thrown seasons off track. If we understand how plants rewrite their memories, we can ensure crops grow regardless of weather. We usually see trees only as shade or timber. But in truth, every leaf contains a library a collection of memories written inside cells.

Nature's secrets are endless. The more we uncover them, the more we realize how small we are. There is still so much to learn from this green diary. When nature's life force joins hands with human intelligence, barren lands can once again turn green and healthy.

## Referances

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