

## **Epigenetics: How Plants Modify DNA Expression**

### **What Is Epigenetics?**

Epigenetics is the modification of gene expression without altering the genome (DNA sequence). It's like flicking a light switch on and off - genes can be turned on and off to enable or disable a specific trait in an organism.

### **Plant Cell Structures**

The two main sites where genes are utilized are within the nucleus and the ribosomes. The nucleus contains all the DNA of the plant and protects it from degradation by enzymes. The ribosomes are molecular structures that are the primary site of protein synthesis.

### **What Does DNA Look Like?**

Picture a twisted ladder or a spiraled staircase. That's what DNA looks like. It's called a double helix. The sides of this ladder are made up of sugar and phosphate molecules, while the rungs are made up of pairs of nitrogenous bases. There are four types of nitrogenous bases, and they pair up in a very specific way: Adenine (A) pairs with Thymine (T), Cytosine (C) pairs with Guanine (G).

So what are genes? Genes contain the instructions to make a specific protein, which in turn performs a particular function. They are a segment of DNA that specifies the order of amino acids to build a particular protein.

### **How Are Genes Expressed?**

DNA undergoes transcription and translation in the cell to create proteins and sustain metabolism. Genes are first transcribed in the nucleus of the cell. This is the process of creating a copy of the DNA sequence (the mRNA strand) to be used outside of the nucleus. Genes are then translated in the ribosomes. This is the process of reading the copy of DNA (mRNA), which is essentially a transcript, and using the RNA sequence to make proteins.

### **How Can Gene Expression Be Turned Off?**

One way to turn off gene expression is DNA methylation. Methyl groups are composed of one carbon atom and three hydrogen atoms. Attaching a methyl group to the DNA sequence prevents DNA translation from occurring. It physically blocks the enzymes from attaching to the DNA sequence, resulting in a particular gene expression being shut off.

Another way to "turn down the volume" of gene expression is through histone modification. DNA is wrapped around proteins called histones. Modifying these histones can change how tightly or loosely DNA is packed, affecting gene expression. The tighter the DNA is packed, the fewer genes will be transcribed simply due to accessibility.

## Why Are Epigenetics Important in Regenerative Organic Agriculture?

DNA expression can be modified under environmental influence. This influence can turn genes on or off and can be affected by environmental factors, like sunlight, temperature, and even stress. Plant DNA expression is modified in several ways to improve: pathogen immunity, pest defence, resistance to drought/frost/etc., flowering time, memory, or transgenerational effects. By influencing which genes/characteristics a plant displays, land managers can select for plants that are better suited to their individual farm context.

## How Do Epigenetics Affect Plants?

### **Surviving Stress:**

Plants can't move to escape stressful conditions, so they've developed clever epigenetic mechanisms to cope. When faced with drought, extreme temperatures or pests, plants can switch certain genes on or off to adapt and survive.

### **Flowering Time:**

Epigenetics helps plants know when it's time to bloom. Environmental cues like day length and temperature can trigger epigenetic changes that influence flowering time, ensuring that plants flower at the optimal moment for reproduction.

### **Defense Mechanisms:**

Plants use epigenetics to bolster their defenses against pathogens. When attacked by pests or pathogens, plants can activate genes that produce defensive chemicals.

### **Memory of Past Events:**

Plants can have a sort of "memory" of past environmental conditions thanks to epigenetics. For instance, if a plant experiences a period of drought, it can remember this stress and adjust its growth patterns and water usage in the future, enhancing its resilience.

### **Transgenerational Effects:**

Epigenetic changes can sometimes be passed down to the next generation. If a parent plant experiences stress, the offspring might inherit epigenetic modifications that help them better cope with similar conditions.