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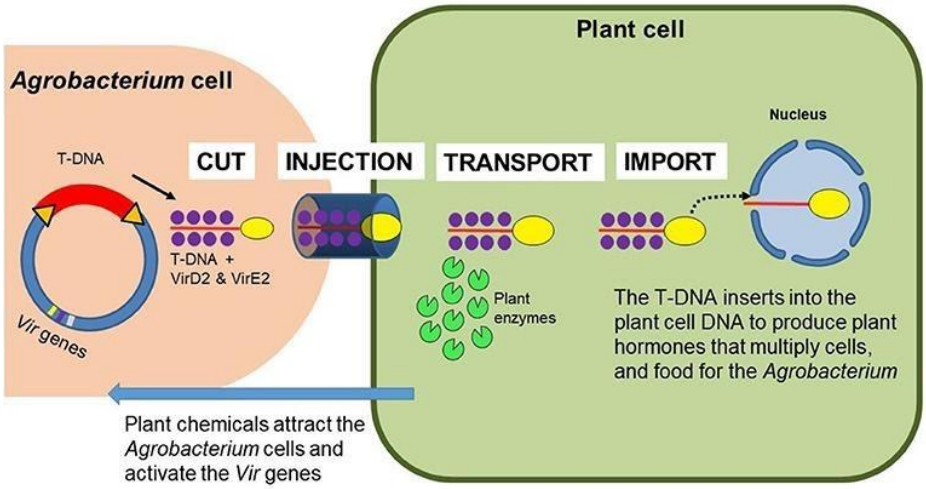
Agrobacterium: Soil Microbe, Plant Pathogen, and Natural Genetic Engineer



Agrobacterium tumefaciens (Agrobacterium for short) is a single-celled microbe that lives in the soil. This microbe has the ability to find a wide range of different plants by moving toward chemicals that are released from naturally occurring plant wounds. (The sugars and phenolic compounds exuded by the wounded plant not only signal the pathogenic opportunity to the bacterium but also induce transcription of the virulence genes). *Agrobacterium* can swim through water films in the soil to reach plants, using

1 structures called flagella, which beat like tails. Although *Agrobacterium* does not have eyes or ears (these would be of little help in the soil anyway), it does have a number of specialized proteins that identify plant chemicals by acting like a very simple nose, which it uses to sniff out a plant. These proteins allow *Agrobacterium* to move in the right direction, toward the plant. When *Agrobacterium* realizes that it is going in the wrong direction, it flaps its flagella randomly, tumbles to point in a new direction, and swims in a straight line. This sequence of swimming and tumbling are repeated until it finds the plant.

Agrobacterium is an expert in communicating with plants, using chemicals rather than words. When the microbe contacts a plant, it releases several different chemicals, which tell the plant to make its surface "sticky." This stickiness allows Agrobacterium to attach

2 to the plant and prepare to invade. At this point, the Agrobacterium switches on a family of Vir (virulence) genes. These Vir genes contain the DNA instructions to make all the tools that Agrobacterium needs to break into the plant cell and smuggle new DNA into the plant cell's nucleus (which contains the plant's genome All the DNA instructions that an organism needs to survive and reproduce. –all of its DNA instructions).

AGROBACTERIUM TRANSFERS DNA INTO THE PLANT

Agrobacterium has a special circular type of DNA, called a plasmid. The small section of DNA that Agrobacterium wants to transfer into the plant genome (called T-DNA, for transfer DNA), is found within the plasmid. One of the Vir genes that is activated when
3 the microbe sticks to the outside of the plant makes a protein called VirD2. VirD2 functions like biological scissors, cutting the T-DNA out of the circular DNA plasmid. VirD2 then attaches to one end of the T-DNA, and drags it into the plant cell, toward the plant nucleus.

Before that can happen, *Agrobacterium* needs to break through the barrier of the plant cell wall. It does this by building a "syringe" with other virulence proteins, called VirB1 through VirB11, and VirD4. Using this protein syringe, *Agrobacterium* injects the T-DNA through the plant cell wall.

Plants have learned to protect themselves against this assault, though. When the plant discovers that *Agrobacterium* is attacking, an army of plant enzymes try to cut up
4 the *Agrobacterium* T-DNA before it can reach the plant cell nucleus. However, *Agrobacterium* is one step ahead, having clothed the T-DNA in a protein armor made of another virulence protein, called VirE2, which prevents the plant enzymes from getting hold of the T-DNA. Once the T-DNA makes it to the plant cell nucleus, it looks for breaks in the DNA (these occur naturally) and inserts itself into the DNA as the plant cell repairs the DNA break. When this happens, the plant cell becomes genetically modified, as it now contains DNA instructions from another organism (the *Agrobacterium*) that will change how the plant behaves and Works –the plant is now a genetically modified organism (GMO).

AGROBACTERIUM MANIPULATES THE PLANT

The T-DNA that Agrobacterium inserts into the plant genome contains instructions that will be copied into every cell that develops from this first genetically modified cell. In fact, some of the new DNA instructions stimulate the plant cell to divide and reproduce, forming large galls, which you can see as unusual growths in the plant.

This is actually how *Agrobacterium* was first discovered–it was found to cause a plant disease called crown gall disease, which limits the growth and yield of crop plants. The *Agrobacterium* T-DNA triggers gall formation by changing the amount of certain
5 plant hormones, which creates a safe environment for the microbe. On top of that, the T-DNA also codes for a recipe: instructions to make *Agrobacterium*'s favorite food. *Agrobacterium* feeds on a family of chemicals that most plants do not know how to make. When the *Agrobacterium* inserts its T-DNA instructions into the plant DNA, it is basically sharing a favorite family recipe with the plant. In summary, Agrobacterium invades the plant, manipulates its DNA, ¡and inserts new instructions that tell the plant how to protect and feed it! While *Agrobacterium* benefits from this interaction, the plant does not. *Agrobacterium* is classed as a pathogen, because it causes disease (also known as pathology) in the plant.

AGROBACTERIUM CAN HELP US TO IMPROVE PLANTS

From what we have told you so far, you can see that genetic engineering is a natural process that *Agrobacterium* uses to manipulate plants. In fact, there is good evidence that many different plants have kept parts of the T-DNA after *Agrobacterium* infection. Scientists can alter *Agrobacterium* T-DNA to remove all of the instructions that harm the plant, and replace them with new DNA instructions that will help the plant! Many successful plants have resulted from this process: crops that are resistant to insect pests; papaya that is resistant to a devastating virus that would have destroyed farms all over Hawaii; golden rice that is fortified with a chemical that we need to make vitamin A, which could prevent millions of children from going blind; non-browning, healthier potatoes that reduce food waste: and many others.

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Despite the many benefits of using *Agrobacterium* to improve crop plants, some groups seek to prevent the use of genetic engineering, and even try to misinform the public about the approach. One of the most common misunderstandings about genetic engineering is the belief that changing the DNA of an organism is unnatural and therefore wrong. However, *Agrobacterium* has been modifying the DNA of plants long before humans learned how to do it. This shows us that changing DNA sequences is a natural process and part of the world around us. By using *Agrobacterium* to modify plant DNA, we are harnessing a natural process to develop crop plants that need fewer pesticides, are more nutritious, and that yield more food using less land. Using less land is a really important consideration because, if we want to avoid the destruction of natural ecosystems, we need to make sure that our farms are as productive as possible. Genetically engineered crop plants can definitely help us to grow more food from less land, meaning that more ecosystems will be protected. Also, long-term studies confirm that genetically modified crops are safe to eat.

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VOCABULARY:

Agrobacterium: Soil Microbe, Plant Pathogen, and Natural Genetic Engineer

Soil: Suelo

Released: Liberados

Stick: Pegajoso

Wounds: Heridas

Syringe: Jeringa

Crops: Cosechas

Farms: Granjas

Harness: Aprovechar

Environment: Medio ambiente

Gall: Agalla