**Ti-Plasmids**

Crown gall is a neoplastic disease of most dicotyledonous plants and is caused by the soil bacterium *Agrobacterium* *tumefaciens.* A large extra-chromosomal plasmid in these bacteria was found to be responsible for its tumor-inducing capacity and was, therefore, called Ti-plasmid.

Ti [plasmids](https://www.sciencedirect.com/topics/medicine-and-dentistry/plasmid) are large, often more than 200 kb long, [catabolic plasmids](https://www.sciencedirect.com/topics/medicine-and-dentistry/catabolic-plasmid) . A [Ti plasmid](https://www.sciencedirect.com/topics/medicine-and-dentistry/ti-plasmid-plant%22%20%5Co%20%22Learn%20more%20about%20Ti%20Plasmid%20%28Plant%29%20from%20ScienceDirect%27s%20AI-generated%20Topic%20Pages) can be transferred by [conjugation](https://www.sciencedirect.com/topics/medicine-and-dentistry/conjugation) to most [*Agrobacterium*](https://www.sciencedirect.com/topics/medicine-and-dentistry/agrobacterium) and some [*Rhizobium*](https://www.sciencedirect.com/topics/medicine-and-dentistry/rhizobium) species.

A major characteristic of a Ti plasmid is that it contains, the vir or virulence genes, which enable a copy of one or more segments (T-DNA) of the Ti plasmid be transferred into plant cells, where it can become integrated into the [plant genome](https://www.sciencedirect.com/topics/medicine-and-dentistry/plant-genome).

The genes encoded by the T-DNA are under eukaryotic control and can be expressed in a plant background. This can result in a plant [cell proliferation](https://www.sciencedirect.com/topics/medicine-and-dentistry/cell-proliferation) (crown gall formation) and the synthesis and secretion of a specific metabolite, of no use for the plant. These metabolites, called opines, are condensation products of amino acids, such as [arginine](https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/arginine) and lysine, and abundant plant metabolites such as [pyruvic acid](https://www.sciencedirect.com/topics/medicine-and-dentistry/pyruvic-acid), [ketoglutaric acid](https://www.sciencedirect.com/topics/medicine-and-dentistry/2-oxoglutaric-acid), [succinate](https://www.sciencedirect.com/topics/medicine-and-dentistry/succinic-acid), and [mannose](https://www.sciencedirect.com/topics/medicine-and-dentistry/mannose).

Thus, crown gall disease is a naturally evolved genetic engineering process. Crown gall formation is the consequence of the transfer integration and expression of genes of T-DNA of *A. tumefaciens* in the infected plant.

**Organization of Ti plasmid**

The Ti plasmid has three important region:-

* T-DNA region: This region has the genes for the biosynthesis of auxin (aux), cytokinin (cyt) and opine (ocs), and is flanked by left and right borders. } T-DNA borders- A set of 24 kb sequences present on either side (right & left) of T- DNA are also transferred to the plant cells. It is clearly established that the right border is more critical for T-DNA transfer.
* Virulence region: The genes responsible for the transfer of T-DNA into host plant are located outside T-DNA and the region is reffered to as vir or virulence region. At least nine vir-gene operons have been identified. These include vir A, vir G, vir B1, vir C1, vir D1, D2, vir D4 and vir E1, E2.
* Opine catabolism region: This region codes for proteins involved in the uptake and metabolisms of opines.
* Besides the above three there is ori region that responsible for origin of DNA replication which permit the Ti plasmid to be stably maintain in *A. tumefaciens.*

**Structure of Ti plasmid**



**The process of T-DNA transfer and it integration into the host plant genome are as follows: -**

1. Signal induction to *Agrobacterium*: - The wounded plant cells release certain chemicals-phenolic compounds and sugars which are recognized as signals by *Agrobacterium*. The signals induced result in a sequence of biochemical events in *Agrobacterium* that ultimately helps in the transfer of T-DNA of T-plasmid.
2. Attachment of *Agrobacterium* to plant cells: - The *Agrobacterium* attaches to plant cells through polysaccharides, particularly cellulose fibres produced by the Bacterium.
3. Production of virulence proteins: - As the signal induction occurs in the *Agrobacterium* cells attach to plant cell, a series of events take place that result in the production of virulence proteins. To start with, signal induction by phenolics stimulates vir A which in turn activates (by phosphorylation) vir G. This induces expression of virulence gene of Ti-plasmid to produce the corresponding virulence proteins (D1, D2, E2, B etc.).
4. Production of T-DNA strand: - The right and left borders of T-DNA are recognized by vir D1/vir D2 proteins. These proteins are involved in the production single-stranded T-DNA (ss DNA), its protection and export to plant cells. The ss T-DNA gets attached to vir D2.
5. Transfer of T-DNA out of *Agrobacterium*: - The ss T-DNA –vir D2 complex in association with vir G is exported from the bacterial cell. Vir B products form the transport apparatus.
6. Transfer of T-DNA into plant cells and integration: - The T-DNA –vir D2 complex crosses the plant plasma membrane.In the plant cells, T-DNA gets covered with vir E2. This covering protects the T-DNA from degradation by nucleases. Vir D2 and vir E2 interact with a variety of plant proteins which influences T-DNA transport and integration. } The T-DNA – vir D2, vir E2- plant protein complex enters the nucleus through nuclear pore complex. Within the nucleus, the T-DNA gets integrated into the plant chromosome.



**References**

* Life Sciences by Pranav Kumar and Usha Mina Pathfinder publication.