



Agrobacterium

Agrobacterium is a genus of Gram-negative bacteria established by H. J. Conn that uses horizontal gene transfer to cause tumors in plants. *Agrobacterium tumefaciens* is the most commonly studied species in this genus. *Agrobacterium* is well known for its ability to transfer DNA between itself and plants, and for this reason it has become an important tool for genetic engineering.

Nomenclatural History

Leading up to the 1990s, the genus *Agrobacterium* was used as a wastebasket taxon. With the advent of 16S sequencing, many *Agrobacterium* species (especially the marine species) were reassigned to genera such as *Ahrensia*, *Pseudorhodobacter*, *Ruegeria*, and *Stappia*.^{[2][3]} The remaining *Agrobacterium* species were assigned to three biovars: biovar 1 (*Agrobacterium tumefaciens*), biovar 2 (*Agrobacterium rhizogenes*), and biovar 3 (*Agrobacterium vitis*). In the early 2000s, *Agrobacterium* was synonymized with the genus *Rhizobium*.^[4] This move proved to be controversial.^{[5][6]} The debate was finally resolved when the genus *Agrobacterium* was reinstated^[7] after it was demonstrated that it was phylogenetically distinct from *Rhizobium*.^{[8][9]} and that *Agrobacterium* species were unified by a unique synapomorphy: the presence of the protelomerase gene, *telA*, which causes all members of the genus to have a linear chromid.^[10] By this time, however, the three *Agrobacterium* biovars had become defunct; biovar 1 remained with *Agrobacterium*, biovar 2 was renamed *Rhizobium rhizogenes*, and biovar 3 was renamed *Allorhizobium vitis*.

Plant pathogen



The large growths on these roots are galls induced by *Agrobacterium* sp.

Agrobacterium tumefaciens causes crown-gall disease in plants. The disease is characterised by a tumour-like growth or gall on the infected plant, often at the junction between the root and the shoot. Tumors are incited by the conjugative transfer of a DNA segment (T-DNA) from the bacterial tumour-inducing (Ti) plasmid. The closely related species, *Agrobacterium rhizogenes*, induces root tumors, and carries the distinct Ri (root-inducing) plasmid. Although the taxonomy of *Agrobacterium* is currently under revision it can be generalised that 3 biovars exist within the genus,

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Scientific classification

Domain:	Bacteria
Phylum:	Pseudomonadota
Class:	Alphaproteobacteria
Order:	Hyphomicrobiales
Family:	Rhizobiaceae
Genus:	<i>Agrobacterium</i> Conn 1942 (Approved Lists 1980)

Type species

<i>Agrobacterium radiobacter</i> (Smith and Townsend 1907) Conn 1942 (Approved Lists 1980)
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Species

- "*Agrobacterium albertimagni*"

Salmassi *et al.* 2002
- Agrobacterium arsenijevicii*

Kuzmanović *et al.* 2019
- "*Agrobacterium bohemicum*"

Zahradnik *et al.* 2018
- Agrobacterium cavarae* Flores-Félix *et al.* 2020

Agrobacterium tumefaciens, *Agrobacterium rhizogenes*, and *Agrobacterium vitis*. Strains within *Agrobacterium tumefaciens* and *Agrobacterium rhizogenes* are known to be able to harbour either a Ti or Ri-plasmid, whilst strains of *Agrobacterium vitis*, generally restricted to grapevines, can harbour a Ti-plasmid. Non-*Agrobacterium* strains have been isolated from environmental samples which harbour a Ri-plasmid whilst laboratory studies have shown that non-*Agrobacterium* strains can also harbour a Ti-plasmid. Some environmental strains of *Agrobacterium* possess neither a Ti nor Ri-plasmid. These strains are avirulent.^[11]

The plasmid T-DNA is integrated semi-randomly into the genome of the host cell,^[12] and the tumor morphology genes on the T-DNA are expressed, causing the formation of a gall. The T-DNA carries genes for the biosynthetic enzymes for the production of unusual amino acids, typically octopine or nopaline. It also carries genes for the biosynthesis of the plant hormones, auxin and cytokinins, and for the biosynthesis of opines, providing a carbon and nitrogen source for the bacteria that most other micro-organisms can't use, giving *Agrobacterium* a selective advantage.^[13] By altering the hormone balance in the plant cell, the division of those cells cannot be controlled by the plant, and tumors form. The ratio of auxin to cytokinin produced by the tumor genes determines the morphology of the tumor (root-like, disorganized or shoot-like).

In humans

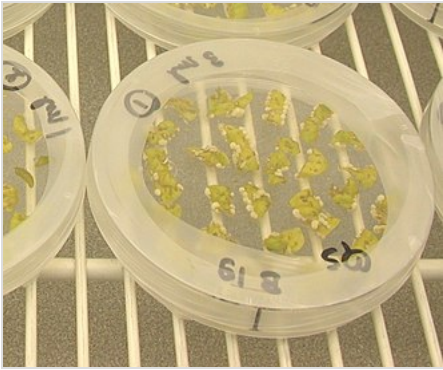
Although generally seen as an infection in plants, *Agrobacterium* can be responsible for opportunistic infections in humans with weakened immune systems,^{[14][15]} but has not been shown to be a primary pathogen in otherwise healthy individuals. One of the earliest associations of human disease caused by *Agrobacterium radiobacter* was reported by Dr. J. R. Cain in Scotland (1988).^[16] A later study suggested that *Agrobacterium* attaches to and genetically transforms several types of human cells by integrating its T-DNA into the human cell genome. The study was conducted using cultured human tissue and did not draw any conclusions regarding related biological activity in nature.^[17]

Uses in biotechnology

The ability of *Agrobacterium* to transfer genes to plants and fungi is used in biotechnology, in particular, genetic engineering for plant improvement. Genomes of plants and fungi can be engineered by use of *Agrobacterium* for the delivery of sequences hosted in T-DNA binary vectors. A modified Ti or Ri plasmid can be used. The plasmid is 'disarmed' by deletion of the tumor inducing genes; the only essential parts of the T-DNA are its two small (25 base pair) border repeats, at least one of which is needed for plant transformation.^{[18][19]} The genes to be introduced into the plant are cloned into a plant binary vector that contains the T-DNA region of the disarmed plasmid, together with a selectable marker (such as antibiotic resistance) to enable selection for plants that have been successfully transformed. Plants are grown on media containing antibiotic following transformation, and those that do not have the T-DNA integrated into their genome will die. An alternative method is agroinfiltration.^{[20][21]}

Transformation with *Agrobacterium* can be achieved in multiple ways. Protoplasts or alternatively leaf-discs can be incubated with the *Agrobacterium* and whole plants regenerated using plant tissue culture. In agroinfiltration the *Agrobacterium* may be injected directly into the leaf tissue of a plant. This method transforms only cells in immediate contact with the bacteria, and results in transient expression of plasmid DNA.^[22]

Agroinfiltration is commonly used to transform tobacco (*Nicotiana*). A common transformation protocol for *Arabidopsis* is the floral dip method:^[23] An inflorescence is dipped in a suspension of *Agrobacterium*, and the bacterium transforms the germline cells that make the female gametes. The seeds can then be screened for antibiotic resistance (or another marker of interest). Plants that have not integrated the plasmid DNA will die when exposed to the antibiotic.^[20]



Plant (*S. chacoense*) transformed using *Agrobacterium*. Transformed cells start forming calluses on the side of the leaf pieces

Agrobacterium is listed as being the vector of genetic material that was transferred to these USA GMOs:^[24]

- Soybean
- Cotton
- Maize
- Sugar Beet
- Alfalfa
- Wheat
- Rapeseed Oil (Canola)
- Creeping bentgrass (for animal feed)
- Rice (Golden Rice)

The transformation of fungi using *Agrobacterium* is used primarily for research purposes,^{[25][26]} and follows similar approaches as for plant transformation. The Ti plasmid system is modified to include DNA elements to select for transformed fungal strains, after co-incubation of *Agrobacterium* strains carrying these plasmids with fungal species.

Genomics

The sequencing of the genomes of several species of *Agrobacterium* has permitted the study of the evolutionary history of these organisms and has provided information on the genes and systems involved in pathogenesis, biological control and symbiosis. One important finding is the possibility that chromosomes are evolving from plasmids in many of these bacteria. Another discovery is that the diverse chromosomal structures in this group appear to be capable of supporting both symbiotic and pathogenic lifestyles. The availability of the genome sequences of *Agrobacterium* species will continue to increase, resulting in substantial insights into the function and evolutionary history of this group of plant-associated microbes.^[27]

History

Marc Van Montagu and Jozef Schell at the University of Ghent (Belgium) discovered the gene transfer mechanism between *Agrobacterium* and plants, which resulted in the development of methods to alter *Agrobacterium* into an efficient delivery system for gene engineering in plants.^{[18][19]} A team of researchers led by Mary-Dell Chilton were the first to demonstrate that the virulence genes could be removed without adversely affecting the ability of *Agrobacterium* to insert its own DNA into the plant genome (1983).^[28]

See also

- Agroinfiltration
- Marc Van Montagu
- *Rhizobium rhizogenes* (formerly *Agrobacterium rhizogenes*)

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Further reading

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External links

- Current taxonomy of *Agrobacterium* species, and new *Rhizobium* names (<http://www.rhizobia.co.nz/taxonomy/not-rhizobia>)

- [Agrobacteria is used as gene ferry \(https://web.archive.org/web/20110520044820/http://www.gmo-safety.eu/basic-info/294.soil-bacterium-gene-transporter.html\)](https://web.archive.org/web/20110520044820/http://www.gmo-safety.eu/basic-info/294.soil-bacterium-gene-transporter.html) - Plant transformation with *Agrobacterium*
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