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# Role of Secretion System in Phytopathogenic Bacteria

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## Introduction

- Secretion is a process by which substances are produced and discharged from the cell, gland or organ for a particular function.
- Bacterial secretion systems (SSs) are protein complexes present on the cell membranes of bacteria for secretion of substances. SSs act as pathogenicity determinants.
- Specifically, they are the cellular devices used by pathogenic bacteria to secrete their virulence factors (mainly of proteins) to invade the host cells.

## Need of bacterial secretions

Secretion systems are essential for phytopathogenic bacteria to produce surface structures for adhesion, aggregation, bacterial motility, cell wall-degrading enzymes, proteases, toxins, and effectors to defeat and reprogram host cells. Moreover, secretion systems arm bacteria to compete against other microbes and equip bacteria with a mechanism to share nucleic acids and influence virulence evolution (Chang *et al.*, 2014).

## Types of Secretion Systems

**One-step mechanism**:

- Takes place in Gram-positive bacteria as these bacteria has inner membrane and no outer membrane.
- The proteins from the cytoplasm of bacteria are transported and delivered directly through the cell membrane into the host cell.

**Two-step mechanism:**

- Takes place in Gram-negative bacteria due to the presence of both inner and outer membranes.

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- The proteins are first transported out of the inner cell membrane, then deposited in the periplasm, and finally through the outer cell membrane into the host cell.

**Protein transport across the inner membrane**

**A.** General secretory pathway (GSP/ Sec)

**B.** Twin-arginine translocation (TAT) pathway

**C.** ATP-binding cassette (ABC) pathway

**Protein translocation across the outer membrane**

**1.** Type I pathway

**2.** Type II pathway

**3.** Type III pathway

**4.** Type IV pathway

**5.** Type V pathway

6. Type VI pathway

**Bacterial Secretion Systems InGram-negative bacteria**

Gram-negative bacteria possess an outer membrane layer which constrains uptake and secretion of solutes and polypeptides. (Chang *et al.*, 2014).

**Type I Secretion System**

- T1SSs allow for the movement of the proteins from cytoplasm to outside the cell in one-step manner.
- TISS transports various molecules, from ions to proteins of various sizes (20-900 k Da).
- It secretesextracellular proteins such as hydrolytic enzymes (proteases and lipases), toxins and non-proteinaceous substrates like cyclic β-glucans and polysaccharides
- *Dickeyachrysanthemi and Erwiniaamylovora*uses a type I secretion system to secrete proteases.
- *Pseudomonasfluorescens*secretes cell adhesion protein (LapA of 900 kDa. )

**Type II secretion pathway**

- It is Two-step secretion systems.
- T2SS is essential for microbes with a soft-rotting lifestyle.
- The T2SS exports enzymes that are involved in degrading the plant cell wall: Pectinases, Endoglucanases, Cellulases.

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- The pectinases and cellulase produced by soft rot *Pectobacterium.*
- *Xanthomonas,Xylellafastidiosa*also encode this system.

**Type III secretion system (T3SS)**

- It is one-step secretion systems.
- Many Gram-negative plant and animal pathogenic bacteria utilize a T3SS as a molecular syringe to inject effector proteins directly into host cells (Fig. 1).
- The effectors manipulations on host cell biological systems are:Cytoskeletal structure, signal transduction, cell cycle progression programmed cell death
- TTSS have been identified in *Ralstoniasolancearum* and *Pseudomonas syringae, Xanthomonascitri,*

**Type IV secretion system**

- The T4SS is homologous to conjugation machinery of bacteria.
- It is capable of transporting both DNA and proteins directly into the host
- It was discovered in *Agrobacterium tumefaciens*, which uses this system to introduce the Ti plasmid and proteins into the host which develops the crown gall (tumour).
- T4SS not distributed in phytoplasmas.
- Type IV system (Type IV pili) have also been found in:
    - *Pseudomonassyringae,*
    - *Xylellafastidiosa*
    - *Xanthomonas*spp. (e.g. *X. vesicatoria*).

**Type V secretion system**

- It is simple and called auto-transporting system
- These have a diverse array of function including the ability to condense host cell actin, modulate apoptosis, producecytotoxins andadhesins.
- T5SS-associated adhesions are found in*Erwiniachrysanthemi and Didymielladadantii*

**Type VI secretion system**

- T6SS is a Syringe like structure designed to deliver effector proteins (Fig. 2) .
- Show structural and functionalhomology to the T4 Bacteriophage (inverted phage tail).
- This system was first characterised in*Vibrio cholerae*and *Pseudomonas aeruginosa.*
- *Erwiniaamylovora*possess Type VI secretion system

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**Fig. 1. Type 3 Secretion**

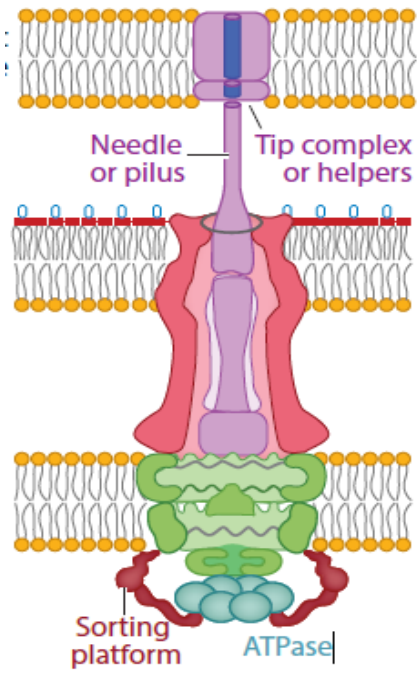
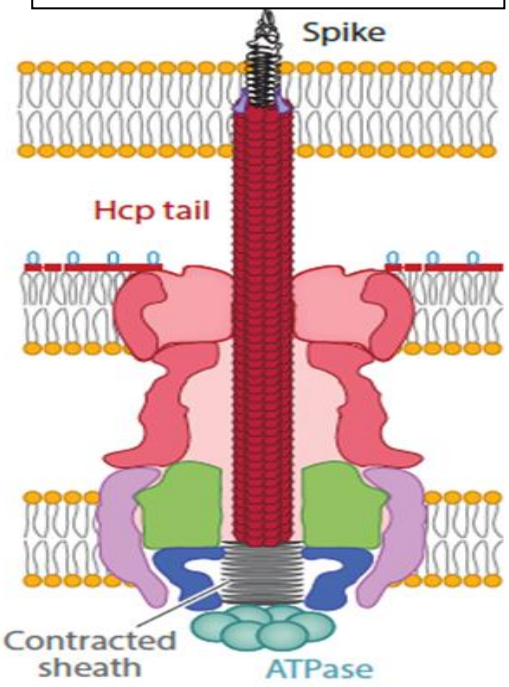



**Fig. 2. Type 6 Secretion System**




**Bacterial Secretion Systems in G+ve bacteria**

This bacterium has inner membrane and no outer membrane**.** The exported proteins are exported from the cytoplasm via the general Secretory (Sec) pathway (Bitter *et al.*, 2009).T7SSs are best known as specialized secretion systems for translocating cargo across membranes of mycolic acid–containing bacteria like acid Mycobacteriaceae, Corynebacteriaceae, and Nocardiaceae

Ex: A T7SS-like system has been characterized in the plant pathogen *Streptomyces scabies*.

**Co-Ordination between Secretion System**

Secretion systems can translocate hundreds of cargos. There is also a higher-level coordination between the different secretion systems. Many pathogens rely on multiple mechanisms of protein secretion. *Erwinia* species require both a T2SS and a T3SS to cause disease. Strains of *Xanthomonas* have T2SS, T3SS and T4SS. E. coli provides an even more astonishing example of coordination between two secretion systems. The pathogen uses a T3SS to inject Tir, which is a receptor for intimin, a T5eSS surface localized adhesin. Together, the two mediate attachment of the pathogen to the host cell (Szczesny*et al.*, 2010).

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## Conclusion

Effectors and other secretions are essential for most phytopathogens. However, the functions and targets for most effectors still remain unknown. This is an open area of research that is critically important for gaining insights into pathogen virulence and host immunity. A better understanding of secretion systems in bacteria could offer new antimicrobial treatments.

## References

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