14.4C: Type III and Type IV Secretion

Type III and IV secretion systems are utilized by pathogenic bacteria to transfer molecules from the bacterial cell to the host cell.

Learning Objectives

- Distinguish between Type III and IV secretion systems

Key Points

- Type III secretion system use a process which injects the secretory molecule into the host cell.
- Type IV secretion systems use a process which is similar to the bacterial conjugation machinery.
- Type IV secretion systems require attachment to the host cell by direct cell-to-cell contact or via a bridge-like apparatus.
- Type IV secretion systems can be used to both transport and receive molecules.
- Type III secretion systems requires a large protein complex to ensure proper transfer of secretory molecules.

Key Terms

- **peptidoglycan**: A polymer of glycan and peptides found in bacterial cell walls.
- **effector**: a small molecule that effects additional molecules
- **bacterial conjugation**: transfer of genetic material between bacterial cells by direct contact
In regards to pathogenicity, secretion in microorganisms such as bacterial species involves the movement of effector molecules from the interior of a pathogenic organism to the exterior. The secretion of specific molecules allows for adaptation to occur, thereby promoting survival. Effector molecules secreted include proteins, enzymes or toxins. The mechanisms by which pathogenic bacteria secrete proteins involve complex and specialized secretion systems. Specifically, Type III and Type IV secretion systems are utilized by gram-negative pathogenic bacteria to transport proteins that function as pathogenic components.

**Type III Secretion Systems**

![Type III Secretion System](https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/14%3A_Pathogenicity/14.4%3A_Da…)

Figure: **Type III Secretion System**: The type III secretion system is characterized by the ability to inject secretory molecules into the host eukaryotic cell.

Type III secretion systems are characterized by the ability to inject a protein directly from the bacterial cell to the eukaryotic cell. It is often compared to the bacterial flagellar basal body which functions as a motor unit and extracellular appendage that is comprised of numerous proteins. The pathogenic bacteria which exhibit this capability contain a critical structural component, considered a protein appendage, that allows the injection of the protein into the host cell. The type III secretion system involves the formation of a complex, roughly ~20 proteins, that reside within the cytoplasmic membrane of the bacterial cell. The process of injecting or transferring the secretory protein from the bacterial cell to the host eukaryotic cell requires a membrane-associated ATPase. Certain species of pathogenic bacteria, including: *Salmonella*, *Shigella*, *Yersinia* and *Vibrio* exhibit type III secretion systems. The system is regulated by Ca2+ concentrations which regulate the opening and closing of gates present in the membrane by which the type III secretion system complexes can utilize for translocation. For example, in *Salmonella*, most commonly associated with *Enteritis salmonellosis*, or food poisoning, the bacteria injects a toxin, AvrA, that inhibits activation of the innate immune system of the host. The mechanism by which AvrA is injected involves exact and proper assembly of proteins which promote invasion of the host cell. Misalignment or improper organization of proteins involved in the type III secretion system prevent injection of secretory substances from the pathogen into the host cell. Another pathogen, *Shigella*, which
Type IV Secretion Systems

Figure: Type IV Secretion System: Type IV secretion systems are characterized by the ability to transfer material using machinery similar to the bacterial conjugation machinery.

Type IV secretion systems are characterized by the ability to transfer secretory molecules via a mechanism similar to the bacterial conjugation machinery. The type IV secretion systems can either secrete or receive molecules. The bacterial conjugation machinery allows transfer of genetic material to occur via direct cell-to-cell contact or by a bridge-like apparatus between the two cells. The type IV secretion system utilizes a process similar to this. However, the exact mechanism(s) this process utilizes is unknown but there is a general understanding.

This specific secretion system can transport both DNA and proteins. An example of a pathogenic bacteria that utilizes the type IV secretion system is Helicobacter pylori. *H. pylori*, most commonly associated with stomach ulcers, attaches itself to epithelial cells within the stomach, then via a type IV secretion system, injects a secretory molecule. The secretory molecule injected into the epithelial cells is an inflammation-inducing agent derived from their own cellular wall. The secretory molecule, peptidoglycan, is recognized by the host system as a foreign substance and activates expression of cytokines which promotes an inflammatory response. This inflammatory response of the stomach is a key characteristic of individuals with ulcers. Peptidoglycan is not the only secretory molecule transferred to the stomach epithelial cells but additional proteins, such as CagA, which function in disruption of host cell cellular activities can be transferred as well.