Type II Secretion Systems (T2SS)

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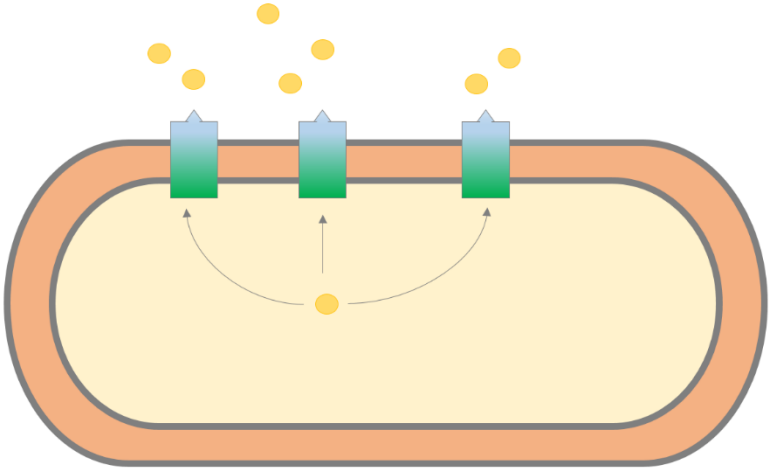


T2SS in Gram-negative bacteria

Bacteria and their relation with the environment

Bacteria are microscopic, unicellular organisms. They are among the oldest known life forms on the planet. There are thousands of different types of bacteria and they can live in any imaginable environment, anywhere in the world. Like all other living beings, bacteria carry out their vital functions: nutrition, relationships and reproduction. All of them are explained in part by their ability to secrete molecules into the environment in which they live.

Secretion.

When we talk about secretion, we are talking about the process of transporting effector molecules, such as proteins, enzymes or toxins, from the inside of the cell to the outside, where they carry out their functions. These molecules are essential for prokaryotic organisms to interact with the environment around them. However, the surface of Gram-negative bacteria is a double membrane, which serves as a barrier that protects them from environmental stresses, but also as a barrier to communicating with the external environment. To solve this problem, they produce dedicated secretion systems. There are multiple mechanisms for the transport of molecules in these bacteria, termed Type I to Type VI. Here, we describe the Type II Secretion System (T2SS).

What is T2SS?

The Type II Secretion System, or T2SS, is a pathway responsible for translocating folded proteins from the periplasm (the space between the inner and outer membrane of Gram-negative bacteria), through the outer membrane, to the extracellular medium.

What is it for?

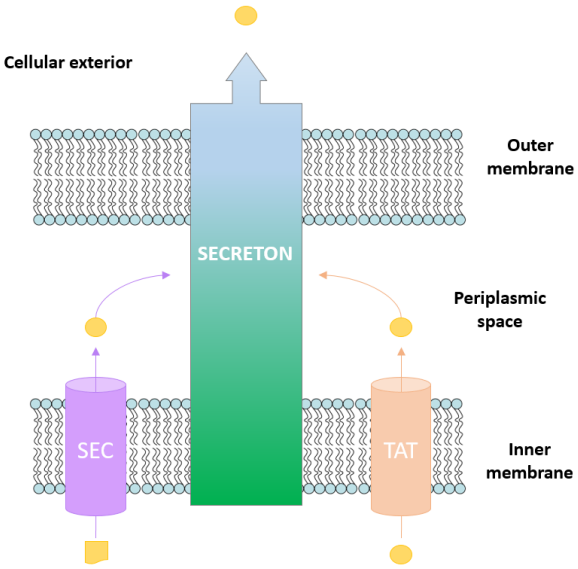
T2SS gives bacteria the ability to secrete large proteins, which are generally hydrolytic enzymes, including proteases, lipases, phosphatases and enzymes that process complex carbohydrates with a range of biological functions, including the degradation of biopolymers. Polymers – large molecules like carbohydrates composed of multiple copies of a compound – are very attractive sources of food, but are too large to be transported through the membrane into the cell where

they can be metabolised. Their use requires them first to be broken down, outside of the cell, into their constituent compounds which are small enough to be transported into the cell. This is achieved by the hydrolytic enzymes. The site of action of T2SS-secreted effectors is primarily extracellular, except for those that act inside eukaryotic cells and are involved in virulence. The number of proteins secreted through the T2SS by any organism is variable and ranges from one to more than twenty, depending on the species.

T2SS structure

The T2SS structure is a sophisticated multiprotein machinery, embedded in the bacterial envelope and responsible for the movement of large molecules from the periplasmic space to the cell exterior. It contains between 12 and 15 different proteins organised as follows:

- An inner membrane platform connected to a peripheral ATPase (not directly involved in protein translocation across the cell envelope such as the T1SS ATPase).
- The ATPase supports the assembly of a periplasmic proteinaceous structure called the pseudopilus.
- Pseudopilus is made of pseudopilins.
- The outer membrane complex forms a channel that gives T2SS substrates access to the extracellular medium.



Protein secretion process via T2SS

How does it work?

T2SS is a two-step process that depends on two other well-known secretion systems: the SEC system (for unfolded proteins) and TAT (for folded proteins, that is, in their native configuration). These systems begin the initial secretion into the periplasmic space, which lies between the inner and outer membranes.

In the second step, folded exoproteins (yellow circles), transiently located in the periplasm, are translocated across the outer membrane by the T2SS (blue/green in the figure).