14.3B: Pili and Pilus Assembly

Learning Objectives

• Describe the function of the pili in regards to pathogenicity

A pilus (Latin for “hair;” plural: pili) is a hairlike appendage found on the surface of many bacteria. The terms pilus and fimbria (Latin for “thread” or “fiber,” plural: fimbriae ) can be used interchangeably, although some researchers reserve the term pilus for the appendage required for bacterial conjugation. All pili are primarily composed of oligomeric pilin proteins.

Dozens of these structures can exist on the bacteria. Some bacterial viruses or bacteriophages attach to receptors on pili at the start of their reproductive cycle. Pili are antigenic. They are also fragile and constantly replaced, sometimes with pili of different composition, resulting in altered antigenicity. Specific host responses to old pili structure are not effective on the new structure. Recombination genes of pili code for variable (V) and constant (C) regions of the pili (similar to immunoglobulin diversity).

Conjugative pili allow the transfer of DNA between bacteria, in the process of bacterial conjugation. They are sometimes called “sex pili”, in analogy to sexual reproduction, because they allow for the exchange of genes via the formation of “mating pairs”. Perhaps the most well-studied is the F pilus of Escherichia coli, encoded by the F plasmid or fertility factor.
Figure: Bacterial Conjugation: A schematic drawing of bacterial conjugation. Conjugation diagram 1- Donor cell produces pilus. 2- Pilus attaches to recipient cell, brings the two cells together. 3- The mobile plasmid is nicked, and a single strand of DNA is then transferred to the recipient cell. 4- Both cells recircularize their plasmids, synthesize second strands, and reproduce pili; both cells are now viable donors.

A pilus is typically 6 to 7 nm in diameter. During conjugation, a pilus emerging from donor bacterium ensnares the recipient bacterium, draws it in close, and eventually triggers the formation of a mating bridge, which establishes direct contact and the formation of a controlled pore that allows transfer of DNA from the donor to the recipient. Typically, the DNA transferred consists of the genes required to make and transfer pili (often encoded on a plasmid), and is a kind of selfish DNA; however, other pieces of DNA often are co-transferred, and this can result in dissemination of genetic traits, such as antibiotic resistance, among a bacterial population. Not all bacteria can make conjugative pili, but conjugation can occur between bacteria of different species.

Some pili, called “type IV pili,” generate motile forces. The external ends of the pili adhere to a solid substrate, either the surface to which the bacteria are attached or to other bacteria, and when the pilus contracts, it pulls the bacteria forward, like a grappling hook. Movement produced by type IV pili is typically jerky, and so it is called “twitching motility,” as distinct from other forms of bacterial motility, such as motility produced by flagella. However, some bacteria, for example Myxococcus xanthus, exhibit gliding motility. Bacterial type IV pilins are similar in structure to the component flagellins of Archaeal flagella.

Attachment of bacteria to host surfaces is required for colonization during infection or to initiate formation of a biofilm. A fimbria is a short pilus that is used to attach the bacterium to a surface. Fimbriae are either located at the poles of a cell or are evenly spread over its entire surface. Mutant bacteria that lack fimbriae cannot adhere to their usual target surfaces and, thus, cannot cause diseases. Some fimbriae can contain lectins. The lectins are necessary to adhere to target cells, because they can recognize oligosaccharide units on the surface of these target cells. Other fimbriae bind to components of the extracellular matrix. Fimbriae are found in both Gram-negative and Gram-positive bacteria. In Gram-positive bacteria, the pilin subunits are covalently linked.
Key Points

- The process of bacterial conjugation allow for the exchange of genes via the formation of “sex pili”.
- All pili are primarily composed of oligomeric pilin proteins.
- Conjugative pili allow the transfer of DNA between bacteria in the process of bacterial conjugation.

Key Terms

- pilus: A hair-like appendage found on the cell surface of many bacteria.