HOW DOES HORIZONTAL GENE TRANSFER (HGT) WORK?

Additional Resource

The transfer of DNA from parent to offspring is described as vertical gene transfer, because the genetic information is passed down the generations. But this is not the only way for an organism to acquire genetic material. Genetic material can also be transferred from one fully formed cell to another via the process of horizontal gene transfer (HGT). Some of the most important genes transferred by HGT between bacteria encode:

1. enzymes or other proteins that confer resistance to antibiotics
2. toxins or other virulence factors that can make a bacterial pathogen cause more serious disease symptoms, or even turn a commensal into a pathogen
3. enzymes of new metabolic pathways that enable the recipient microbe to use novel nutrients and possibly colonise a new niche.

Bacteria use three main methods to exchange genetic material: Transformation, Transduction and Conjugation.

Transformation is the process by which bacteria take up foreign DNA from their environment (eg released by other dying cells) and stably integrate it into their genome (Note: bacteria that can take up DNA from the environment are termed competent). If this foreign DNA contains genes, they give the bacteria new properties (we call these properties phenotypes) such as antibiotic resistance.

Transduction provides an alternative way for bacteria to acquire foreign DNA. In contrast to transformation this process is mediated by a bacteriophage. On a previous Step, you explored the way in which bacteriophages infect bacterial cells. In transduction, mistakes during the assembly process lead to packaging of host DNA (as opposed to phage DNA) inside the phage head structure. The phage is capable of binding to host receptors and injecting this 'packaged' DNA into a new host, however it is defective because the DNA is bacterial in origin (not phage) and is therefore not infectious. If this foreign DNA is stably integrated into the host genome the bacteria may gain a new phenotype, such as antibiotic resistance.

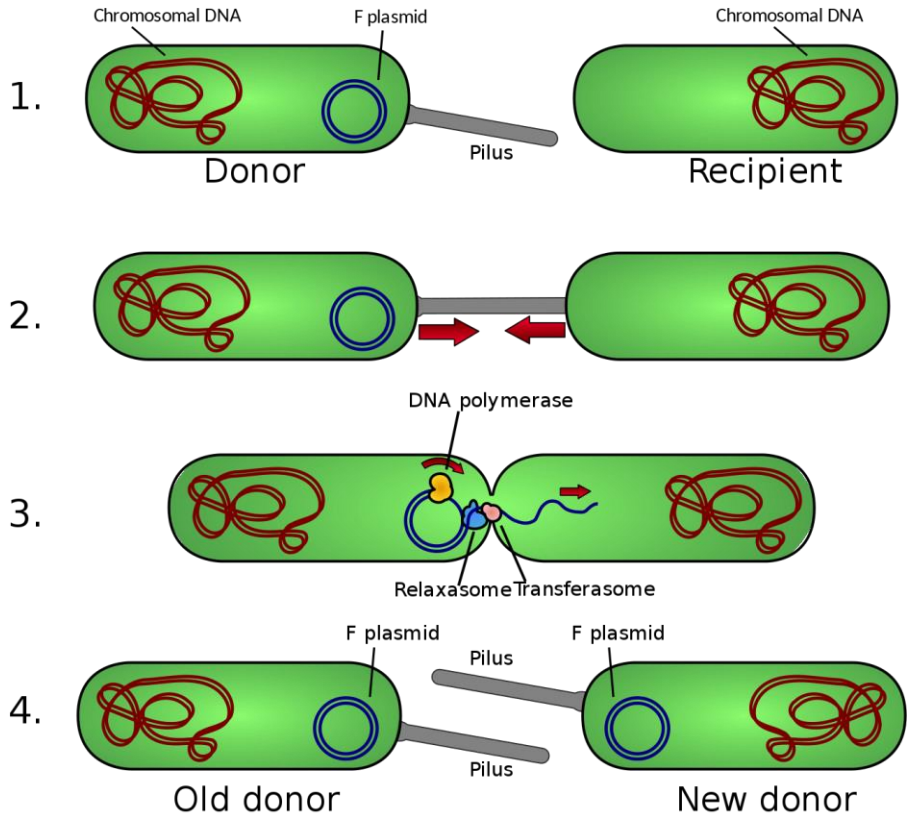

Figure 1: Schematic drawing of bacterial conjugation ©Adenosine [CC BY-SA 3.0].

The third HGT mechanism is called **conjugation** (see diagram above). In this process, a plasmid is transferred from a donor cell to a recipient cell via a long, specialised appendage (the **sex pilus**), produced by the donor cell (1). The sex pilus retracts (2), bringing the cells closer together and plasmid DNA is transferred as a single stranded molecule (3), then converted back into its double stranded form in the recipient cell (Note: you may see conjugation referred to as a form of sexual gene transfer because it requires two cells to make a direct connection, but it is not the same as sexual reproduction). The genes required for building the conjugation machinery are located on **conjugative plasmids**, which mediate their own transfer and then multiply in the new cell, ready for transfer to the next recipient (4). An important class of conjugative plasmids are the R plasmids, which carry antibiotic resistance genes. A single R plasmid can collect many different antibiotic resistance genes: multidrug resistant plasmids are commonly found in hospitals (where antibiotics are used every day), farms (where antibiotics may be used to prevent infections or promote growth of livestock) and in the wastewater that leaves these sites.