Topic: Genetic Recombination in Bacteria

B.Sc. Botany (Hons.) I

Group: C

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Genetic Recombination in Bacteria

Recombination in bacteria will involve transfer of genetic material from one bacterial cell to another. Three types of bacterial recombination result in a change in the DNA of recipient organisms. The proteins expressed by the new genes lead to new physiological characteristics in the bacteria.

The following three methods involved in the genetic recombination of bacteria are -

i. Conjugation
ii. Transformation
iii. Transduction

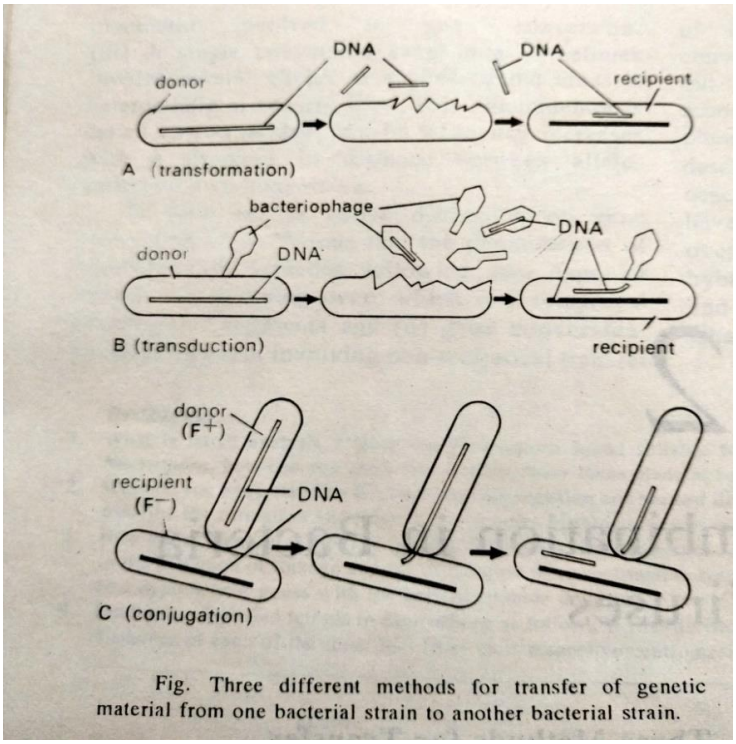

Fig. Three different methods for transfer of genetic material from one bacterial strain to another bacterial strain.

i. Conjugation

Bacterial conjugation was first postulated in the 1940s by Joshua Lederberg and Edward Tatum. The essential feature of the process is that two bacterial cells come together and mate such that a gene transfer occurs between them. One cell, the donor cell (F^+), gives up DNA; and another cell, the recipient cell (F^-), receives the DNA. The transfer is nonreciprocal, and a special pilus called the sex pilus joins the donor and recipient during the transfer. The DNA most often transferred is a copy of the F factor plasmid. The factor moves to the recipient, and when it enters the recipient, it is copied to produce a double-stranded DNA for integration. The channel for transfer is usually a special conjugation tube formed during contact between the two cells.

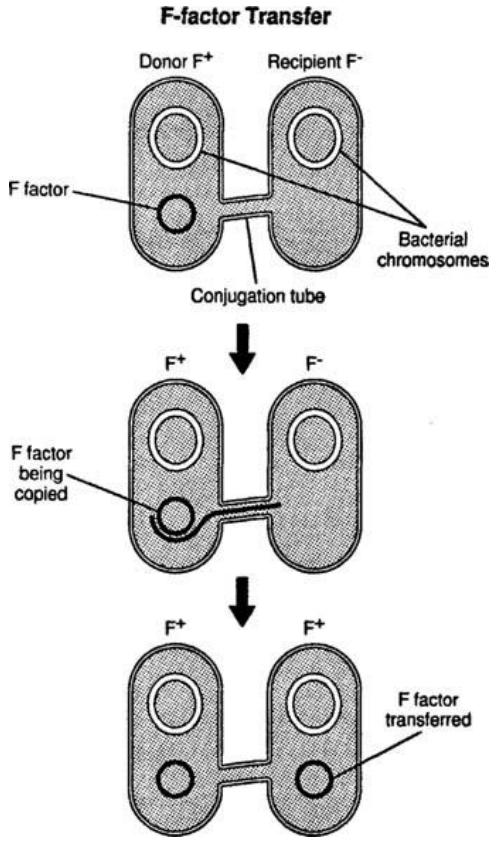

Fig. The process of bacterial conjugation using the F factor plasmid.

Certain donor strains of bacteria transfer genes with high efficiency. In this case, the F factor acts as an episome and integrates itself into the bacterial chromosome. Under these conditions, chromosomal genes are transferred to the recipient cell, and the donor is called a high frequency of recombination (Hfr) donor. During normal conjugation, the donor cell can become a recipient cell if the F factor is transferred during the conjugation. However, during Hfr conjugation, the F factor is rarely transmitted, and the recipient cell does not become a donor cell. The exception occurs if the complete chromosome is transferred, a process requiring about 100 minutes in *E. coli*. In this case, the F factor is transferred and the recipient becomes a donor cell.

During some instances of conjugation, the F plasmid leaves the bacterial chromosome carrying an excised piece of chromosomal DNA The plasmid carrying the chromosomal DNA is called an F' plasmid**.** If the F' plasmid is transferred to a recipient gene during conjugation, the donor bacterial genes will also be transferred. This type of conjugation is important because it accounts for the spread of certain bacterial genes through a bacterial population. The process is called sexduction.

ii. Transformation

Bacterial transformation was discovered by Frederick Griffith in 1928. Griffith worked with the *Pneumococci* that cause bacterial pneumonia. He discovered that if he mixed fragments of dead pathogenic pneumococci with specimens of live harmless pneumococci, the harmless bacteria took on genes of the bacterial fragments and became pathogenic. Griffith's work with pneumococci was among the first demonstrating that bacteria could undergo genetic changes.

Scientists now recognize that when bacteria undergo lysis, they release considerable amounts of DNA into the environment. This DNA may be picked up by a competent cell, that is, one capable of taking up the DNA and undergoing a transformation. To be competent, bacteria must be in the logarithmic stage of growth, and a competence factor needed for the transformation must be present.

During transformation, a competent cell takes up DNA and destroys one strand of the double helix. A single-stranded fragment then replaces a similar but not identical fragment in the recipient organism, and the transformation is complete. Transformation has been studied in detail in *Streptococcus pneumoniae* and *Haemophilus influenzae*. It can be encouraged in the

laboratory by treating cells with heat and calcium chloride, a process that increases the permeability of the cell membrane to DNA.

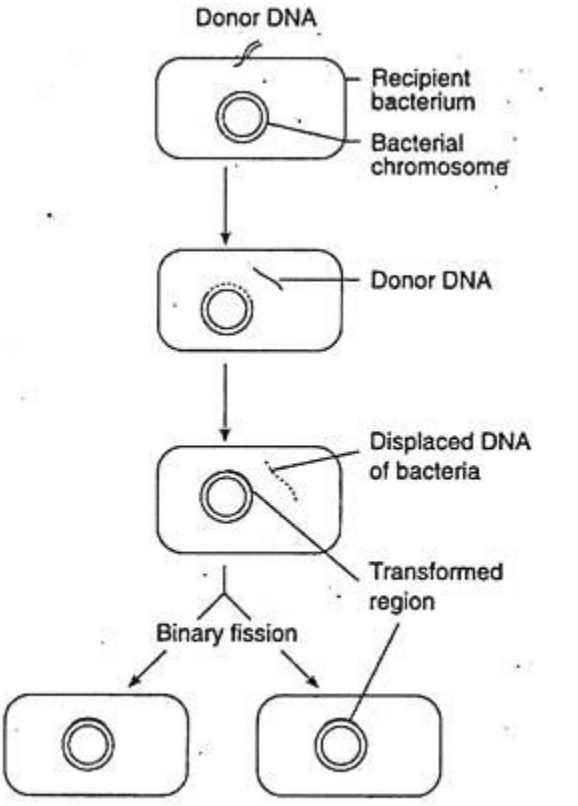

Fig. Diagrammatic representation of Transformation

iii. Transduction

The third important kind of bacterial recombination is transduction**.** In transduction, bacterial viruses (also known as bacteriophages) transfer DNA fragments from one bacterium (the donor) to another bacterium (the recipient). The viruses involved contain a strand of DNA enclosed in an outer coat of protein.

After a bacteriophage (or phage) enters a bacterium, it may encourage the bacterium to make copies of the phage. At the conclusion of the process, the host bacterium undergoes lysis and releases new phages. This cycle is called the lytic cycle**.** Under other circumstances, the virus may attach to the bacterial chromosome and integrate its DNA into the bacterial DNA. It may remain here for a period of time before detaching and continuing its replicative process. This cycle is known as the lysogenic cycle. Under these conditions, the virus does not destroy the

host bacterium, but remains in a lysogenic condition with it. The virus is called a temperate phage, also known as a prophage. At a later time, the virus can detach, and the lytic cycle will ensue.

There are two types transduction-

i. Generalized transduction
ii. Specialized transduction

i. Generalized transduction

During generalized transduction, a phage assumes a lysogenic condition with a bacterium, and the phage DNA remains with the chromosomal DNA. When the phage replicates, however, random fragments of the bacterial DNA are packaged in error by new phages during their production. The result is numerous phages containing genes from the bacterium in addition to their own genes. When these phages enter a new host bacterium and incorporate their DNA to the bacterial chromosome, then they will also incorporate the DNA from the previous bacterium, and the recipient bacterium will be transduced. It will express not only its genes, but also the genes acquired from the donor bacterium.

ii. Specialized transduction

A second type of transduction is called specialized transduction**.** In this case, the lysogenic cycle ensues as before. When the phage DNA breaks away from the bacterial DNA, however, it may take with it a small amount of the bacterial DNA (perhaps 5 percent). When the phage DNA is used as a template for the synthesis of new phage DNA particles, the bacterial genes are also reproduced. When the phages enter new bacterial cells, they carry the bacterial genes along with them. In the recipient bacterium, the phage and donor genes integrate into the bacterial chromosome and transduce the recipient organism. Specialized transduction is an extremely rare event in comparison to generalized transduction because genes do not easily break free from the bacterial chromosome.

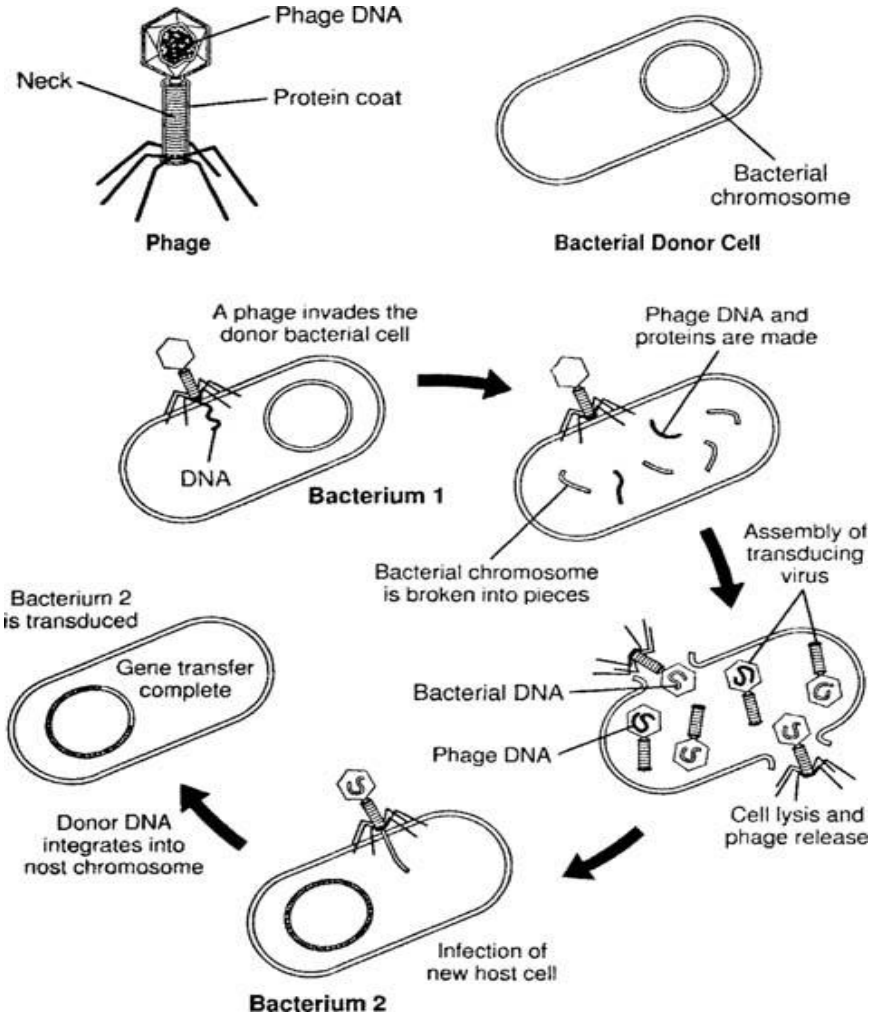

Fig. Generalized transduction involving a bacterial virus (bacteriophage) and a donor bacterium.