# Genetic Recombination of Bacteria

The three main processes involved in the genetic recombination of bacteria. The processes are: 1. Conjugation 2. Transformation 3. Transduction.

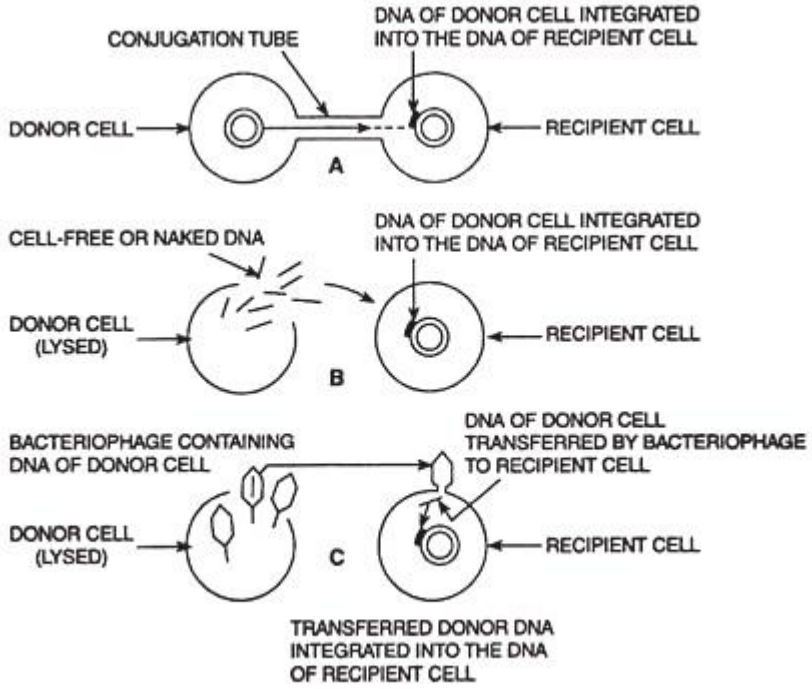


**FIG. 29.1.** Three processes of genetic recombination in bacteria. **A.** conjugation; **B.** transformation, and **C.** transduction.

## Conjugation:

Lederberg and Tatum (1946) discovered conjugation in E. coli and its detailed studies were made by Woolman and Jacob (1956). Conjugation, is a process by which genetic material is transferred from one bacterial cell ("donor cell" or "male cell") to another ("recipient cell" or "female cell") through a specialized intercellular connection called sex-pilus or conjugation tube.

The maleness and femaleness of bacterial cells are determined by the presence or absence of F-plasmid (also called F-factor or sex factor). F- plasmid, an extra chromosomal genetic material, is always present in the cytoplasm of donor or male cells, and the latter develop specialized cell surface appendages called F-pili or sex-pili under the control of F-plasmid. Recipient or female cells always lack F-pIasmids and, therefore, F-pili are not present on their surface.

### F-plasmid or F-factor can exist in two different states:

(i) The autonomous state in which it lies free in the cytoplasm and replicate independent of the bacterial chromosome (DNA); a donor or male cell containing F- factor in autonomous state is called $F^+$ cell, and

(ii) The integrated state in which it is integrated (inserted) into the bacterial chromosome (DNA) and replicate along with it; a donor or male cell containing F-factor in integrated state is called Hfr cell (for high frequency recombination) or high frequency male cell. However, the recipient or female cell lacks F-factor and this is called $F^-$ cell.

***1. Conjugation between a $F^+$ (donor) cell and a $F^-$ (recipient) cell:***

In conjugation between a $F^+$ (donor) cell and a $F^-$ (recipient) cell, it is the autonomous F-factor (F-plasmid) which is transferred, never the bacterial DNA (Fig. 29.2). When the two cells ($F^+$ and $F^-$) come close to each other, the F-pilus of the $F^+$ (donor) cell attaches with the $F^-$ (recipient) cell and acts as a conjugation tube.

Simultaneously, the double-stranded circular F-factor DNA is nicked at a specific point, and begins to replicate producing a single-stranded copy of the F- factor DNA, which migrates through the tube into the cytoplasm of the $F^-$ (recipient) cell.

It becomes double- stranded, and circulars and lies free in the cytoplasm thus rendering the recipient cell to become $F^+$ donor cell. In this way, mixing a population of $F^+$ (donor) cells with a population of $F^+$ (recipient) cells results in the conversion of virtually all the cells in the population becoming $F^+$ (donor) cells.

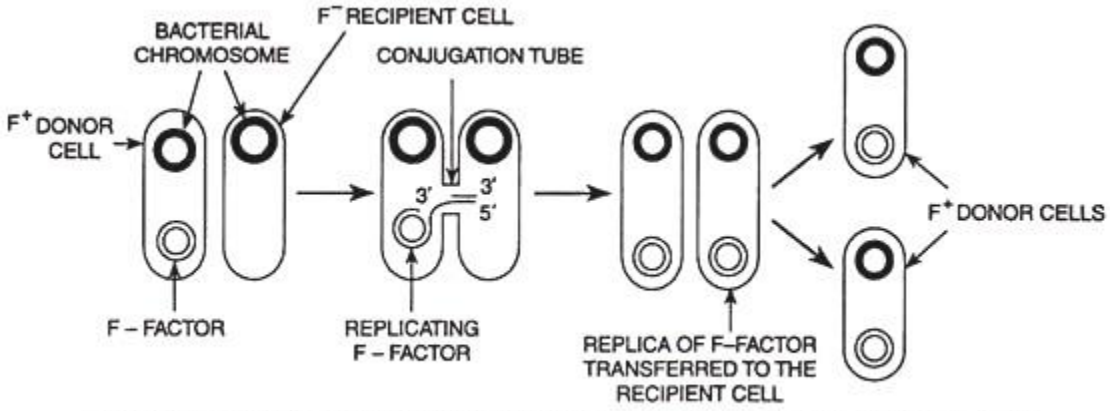


**FIG. 29.2.** Diagrammatic representation of conjugation between $F^+$ (donor) cell and $F^-$ (recipient) cell.

***2. Conjugation between Hfr Donor Cells and Recipient ($F^-$) Cell:***

The Hfr donor cells are considered to be fertile because, unlike $F^+$ (donor) cells, their chromosomal segments are transferred from donor to recipient cells and the F-factor remains in situ.

When the two cells (Hfr and $F^-$) come in contact, a conjugation tube develops between them. The circular DNA of Hfr donor cell is nicked and replication is initiated. The integrate F-factor always lies at the rear end of the DNA molecule. The replication of DNA starts towards the end near the conjugation tube and the newly synthesized single strand starts migrating through the tube into the recipient ($F^-$) cell.

In nature, the mating of two cells exists for a short period and gets interrupted resulting in the migration of only a portion of the donor DNA into the recipient cell. Since the F-factor lies at the rear end of the molecule, it is rarely transferred to the recipient cell.

The genes of the newly entered DNA fragment may replace the homolgous genes of the DNA of the recipient cell, resulting in a recombinant genetic material. The newly formed recombinant genetic material now possesses those male characters that have been transferred through recombination with the migrated DNA fragment (Fig. 29.3).

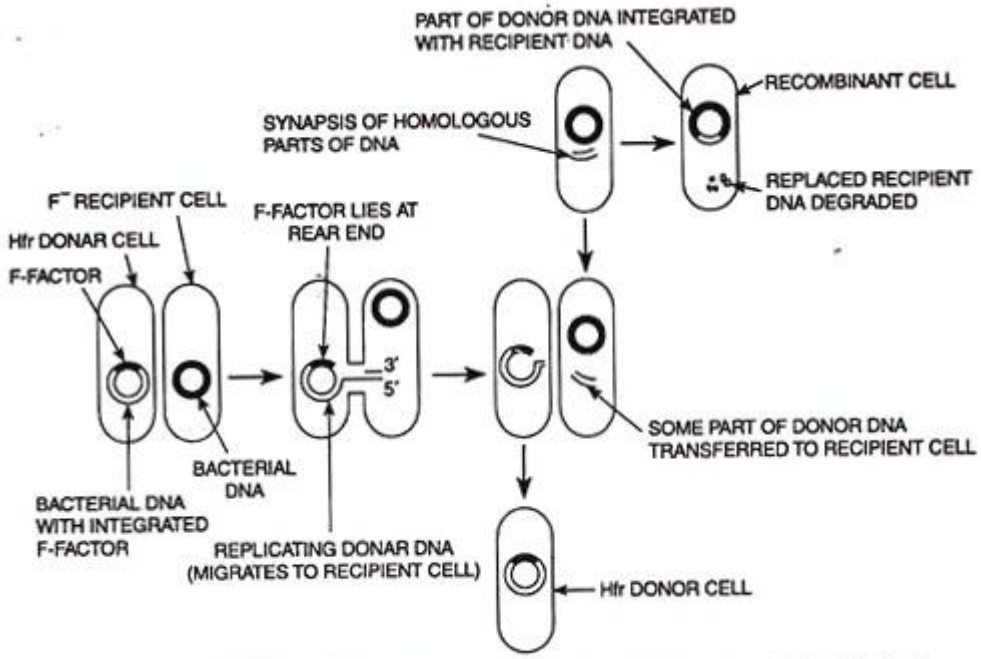


FIG. 29.3. Diagrammatic representation of conjugation between Hfr donor cell and F⁻ (recipient) cell.

***3. Conjugation between F' (F-prime) Male and F⁻ (Recipient) Cell (Sex-Duction):***

Existence of Hfr donor cells is not absolute. The F-factor integrated into the bacterial DNA of Hfr donor cells may dissociate and become free in the cytoplasm (Fig. 29.4).

The dissociation may be occasionally anomalous during which the dissociated F-factor may bring with it some genes of the bacterial chromosome. Adelberg and Burns (1958) first identified such a modified F-factor and called it F' ("F-prime") factor; the donor cell possessing this factor is called F' (F-prime) male.

When a F' male conjugates with F⁻ (recipient) cell, the F'-factor is transferred from donor to the recipient cell, and such a recipient bacterial cell becomes heterozygous (merozygous) for that part of the bacterial chromosome, which the F'- factor had obtained during its anomalous dissociation.

Transfer of F'-factor to recipient cell apparently occurs by the same mechanism as F-factor, transfers during in F⁺ and F⁻ mating and chromosome transfer in Hfr and F⁻ cell mating. Genetic recombination of this type, mediated by F'-factor, is called sex-duction or F-duction.