
Chapter 2.3. General Bacteriology: Bacterial Genetics

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CHAPTER PREVIEW

- Mutation
- Gene Transfer
 - Transformation
 - Transduction
 - Lysogenic Conversion
 - Conjugation

PRINCIPLES OF BACTERIAL GENETICS

Bacterial DNA is present in the chromosome as well as in extrachromosomal genetic material as a plasmid.

- **Chromosome:** Bacteria possess a single haploid chromosome, comprising of coiled circular double-stranded DNA. Bacteria do not have a true nucleus; but the genetic material is located in an irregularly-shaped region called the nucleoid
- **Plasmids:** They are the extrachromosomal ds circular DNA molecules that exist in a free state in the cytoplasm of bacteria. They are capable of replicating independently. They may contain genes that code for resistance to various antimicrobial agents.

Bacteria acquire new genes including those that code for drug resistance either by—(i) mutation or (ii) gene transfer from other bacteria.

MUTATION

A mutation is a random, undirected heritable variation caused by a change in the nucleotide sequence of the genome of the cell. Mutations can be spontaneous or induced by physical or chemical agents.

Impact: Mutation can affect any gene and hence may modify any characteristic of the bacterium, for example—

- Loss of ability to produce capsule or flagella

- Loss of virulence
- Alteration in colony morphology
- Alteration in drug susceptibility.

Detection: Mutation can be detected by gene sequencing. Other less commonly used phenotypic methods include—(i) fluctuation test, (ii) replica plating method, (iii) Ames test.

GENE TRANSFER

Gene transfer occurs between bacteria by four distinct methods, such as:

1. Transformation (uptake of naked DNA)
2. Transduction (through bacteriophage)
3. Lysogenic conversion
4. Conjugation (plasmid mediated via conjugation tube).

Transformation

When bacteria die, the cell wall gets lysed and the DNA fragments are released to the surrounding environment.

- Transformation is a natural process of random uptake of free DNA fragment from the surrounding medium by a bacterial cell and incorporation of this DNA fragment into its chromosome in a heritable form
- **Griffith experiment:** It was an experiment performed by Griffith (1928) on mice using pneumococci and provided direct evidence of transformation
- Transformation has been studied in certain bacteria—*Streptococcus*, *Bacillus*, *Haemophilus*, and *Pseudomonas*, etc.

Transduction

Transduction is defined as the transfer of a portion of DNA from one bacterium to another by a bacteriophage.

Mechanism of transduction: Bacteriophage (or phage) is a virus that infects and multiplies inside the bacterium

- During the transfer of phage from one bacterium to other, a part of the host DNA may accidentally get incorporated into the phage and then gets transferred to the recipient bacterium
- This leads to acquisition of new characters by the recipient bacterium coded by the donor DNA.

Life cycles of phage: After entering into a new bacterium, the phage can perform two types of life cycle.

1. *Lytic or virulent cycle:* The phage multiplies in host cytoplasm, produces a large number of progeny phages, which subsequently are released causing lysis and death of the host cell. In this cycle, inserting a new gene to the bacterium is difficult
2. *Lysogenic or temperate cycle:* Here, the phage DNA remains integrated with the bacterial chromosome and multiplies synchronously with bacterial DNA
 - The phage DNA when transferring to a new bacterium gets disintegrated from the parent bacterial chromosome and in the process, may take up a few bacterial genes
 - These bacterial genes along with the phage DNA get transferred to a new bacterium

- The donor bacterial genes can provide several properties to the new bacterium such as coding for drug resistance (e.g. plasmid coded penicillin resistance in staphylococci).

Lysogenic Conversion

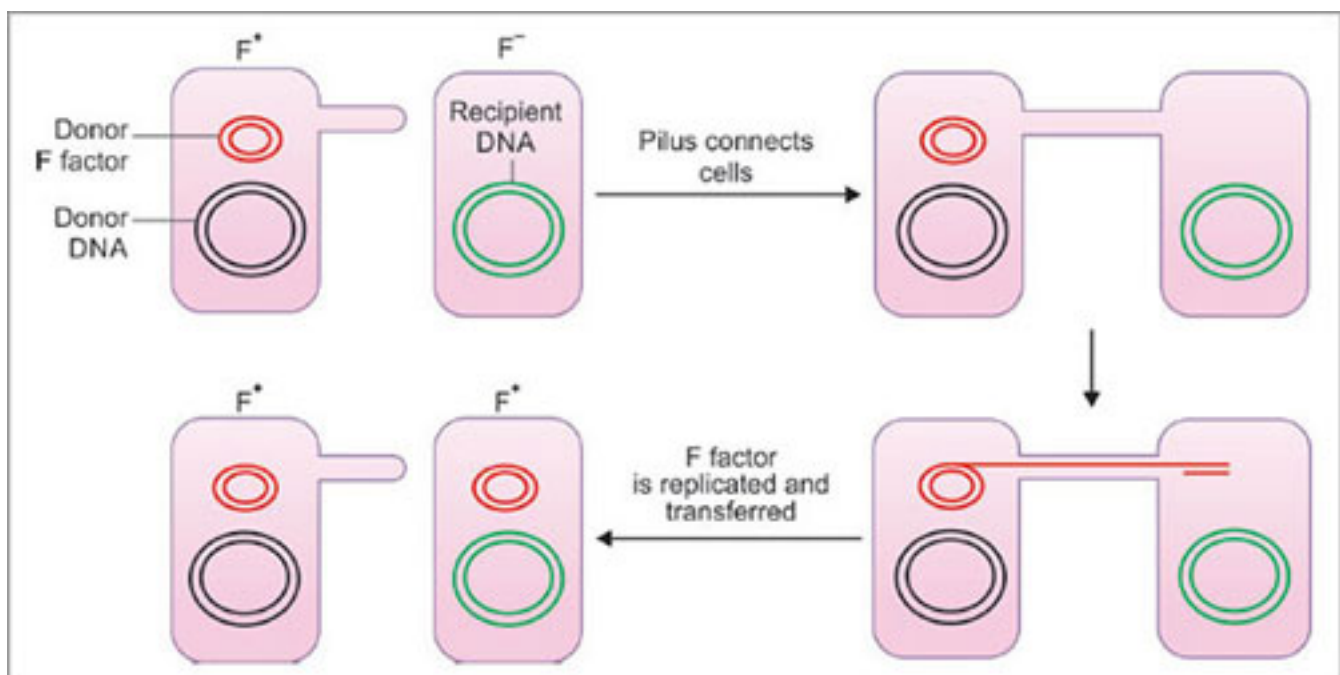
Here, the phage DNA which is integrated into the host bacterial chromosome (during the lysogenic cycle), itself codes for several virulence factors such as diphtheria toxin, cholera toxin, etc. When the bacteriophage infects a new host, the virulence genes also get transferred.

Conjugation

Conjugation refers to the transfer of genetic material from one bacterium (donor) to another bacterium (recipient) through a conjugation tube (**Fig. 2.3.1**).

- **F factor:** The donor bacterium contains a special type of plasmid called, the F factor or fertility factor; which encodes a type of pilus called sex pilus
- **Conjugation tube:** The sex pilus forms the conjugation tube when a donor bacterium comes in contact with the recipient bacterium
- **Transfer of F factor:** The donor F factor gets replicated and a copy moves to the recipient bacterium through the conjugation tube. As a result, the recipient bacterium becomes a donor bacterium (as it acquires the F factor) and the process continues
- **Transfer of other genes:** In some cases, along with the F factor, few other donor genes coding for virulence or drug resistance, etc. may also get transferred
- **Role in drug resistance:** Conjugation is the most common mechanism of the transfer of drug resistance genes in bacteria. Several drug resistance genes can be transferred together along with the F factor, which is the main reason for the emergence of **multidrug resistance** in bacteria.

Fig. 2.3.1. Bacterial conjugation.



EXPECTED QUESTIONS

1. I. Write short notes on:

1. Transformation.
2. Transduction.
3. Conjugation.

2. II. Multiple Choice Questions (MCQs):

1. **The most common method to transfer drug-resistant genes is ____.**
 - a. Transformation
 - b. Transduction
 - c. Lysogenic conversion
 - d. Conjugation
2. **Diphtheria toxin is transferred between bacteria by which of the following method?**
 - a. Transformation
 - b. Transduction
 - c. Lysogenic conversion
 - d. Conjugation
3. **The transfer of bacterial genes through bacteriophage is called as ____.**
 - a. Transformation
 - b. Transduction
 - c. Lysogenic conversion
 - d. Conjugation
4. **Plasmid coded penicillin resistance in staphylococci is transferred between bacteria by which of the following method?**
 - a. Transformation
 - b. Transduction
 - c. Lysogenic conversion
 - d. Conjugation

Answers

1. d	2. c	3. b	4. b
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