

# INTRODUCTION

- Genetic recombination - transfer of DNA from one organism (donor) to another organism (recipient). The transferred donor DNA may then be integrated into the recipient's genetic material by various mechanisms
- Like mutation, genetic recombination contributes to genetic diversity of a population, which is the source of variation in evolution

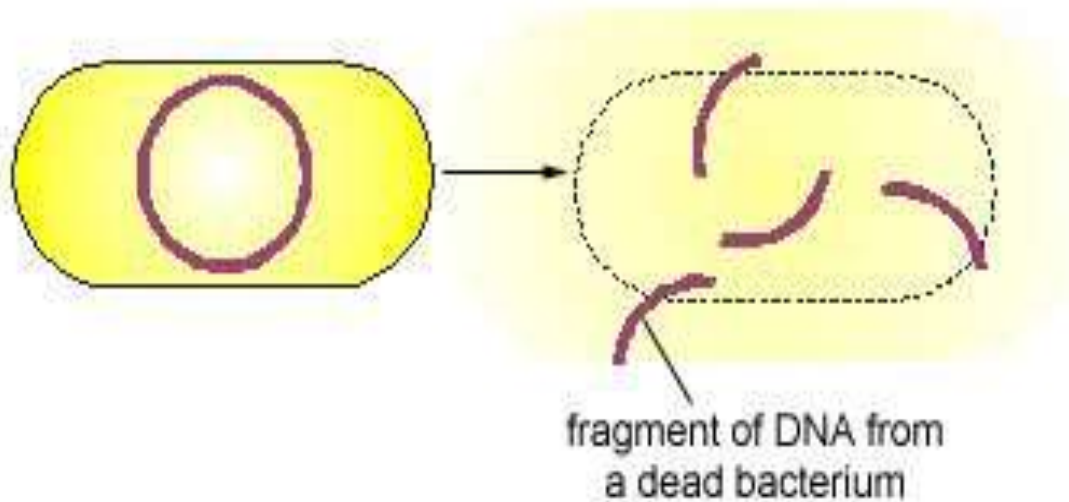
# BACTERIAL RECOMBINATON

- Bacterial recombination occurs in three ways
  - ❖ Transformation
  - ❖ Transduction
  - ❖ Conjugation

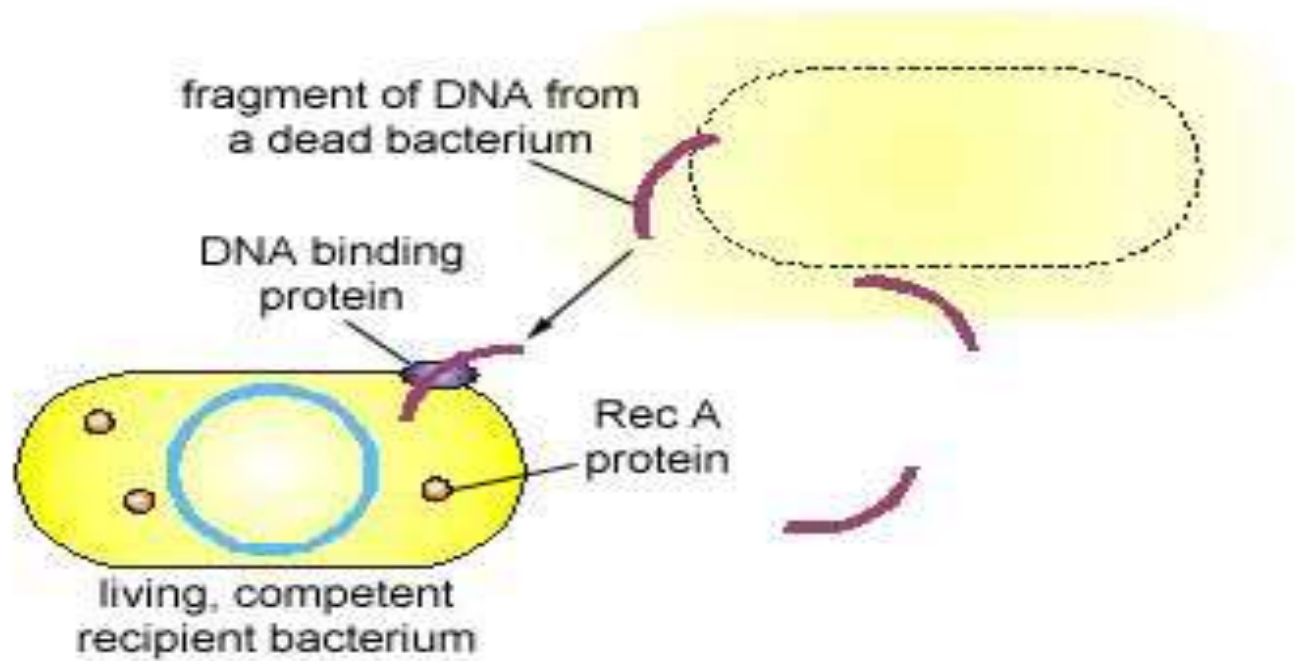
# TRANSFORMATION

- Genetic recombination in which a DNA fragment from a dead, degraded bacterium enters a competent recipient bacterium and it is exchanged for a piece of the recipient's DNA.
- Involves 4 steps

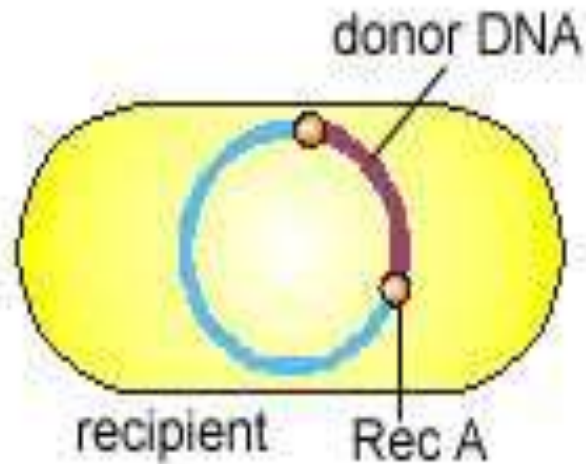
# The 4 steps in Transformation



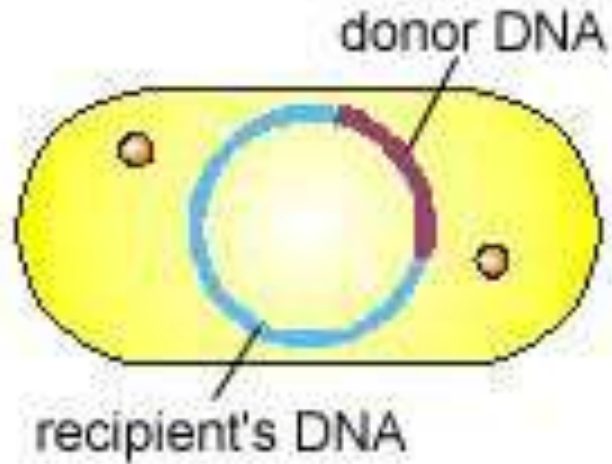
1. A donor bacterium dies and is degraded



2. A fragment of DNA from the dead donor bacterium binds to DNA binding proteins on the cell wall of a competent, living recipient bacterium

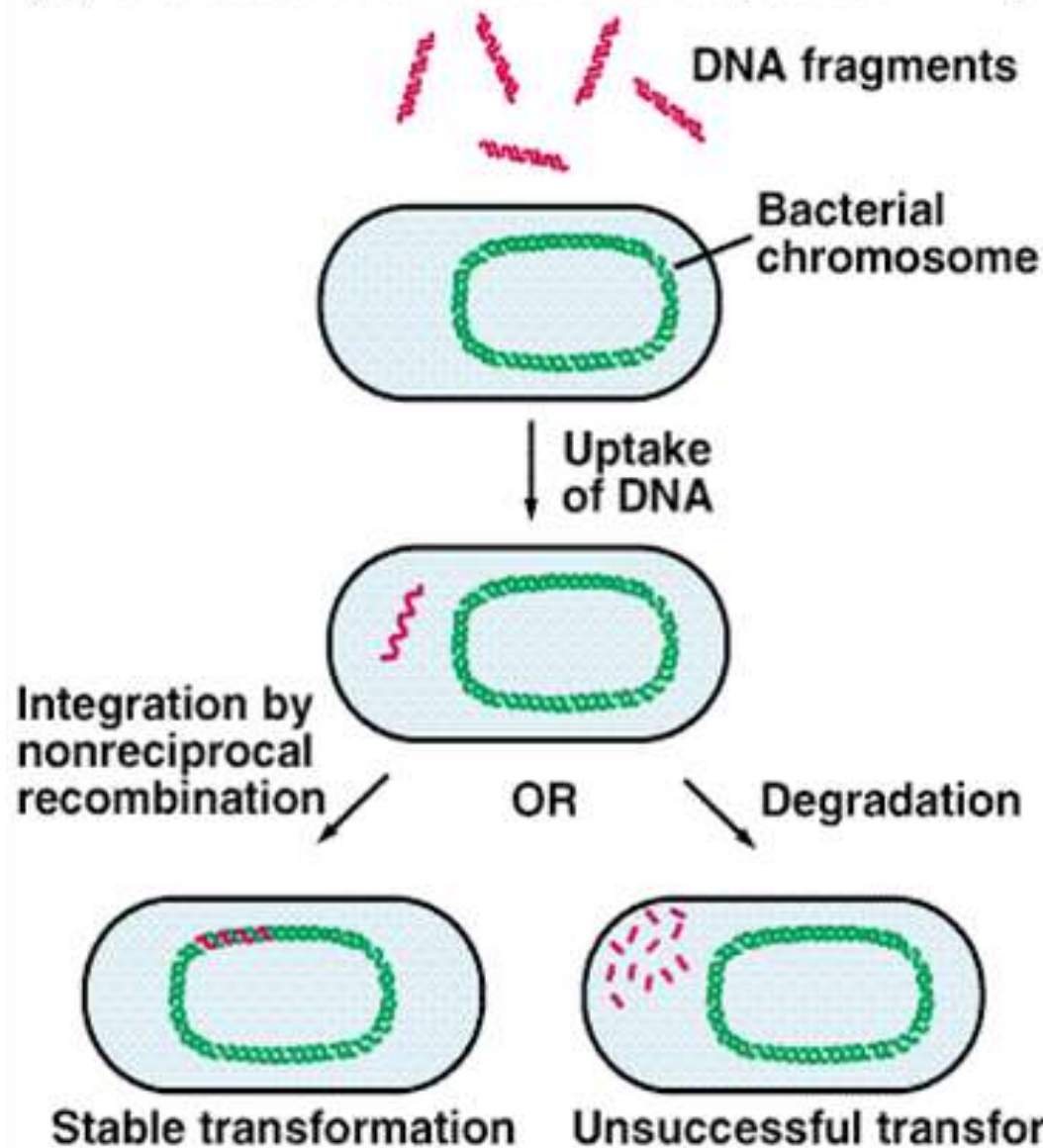


3. The Rec A protein promotes genetic exchange between a fragment of the donor's DNA and the recipient's DNA

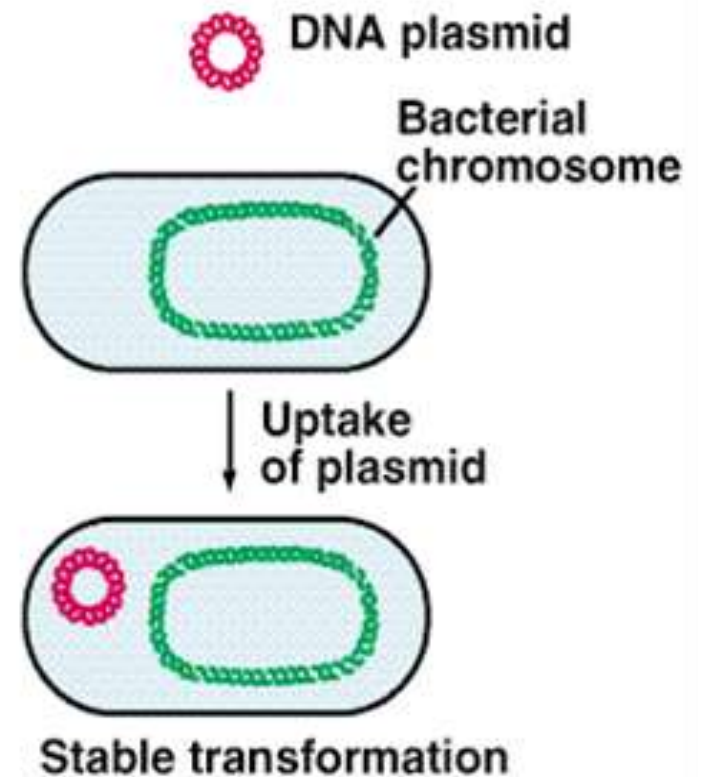


4. Exchange is complete

(a) Transformation with DNA fragments



(b) Transformation with a plasmid



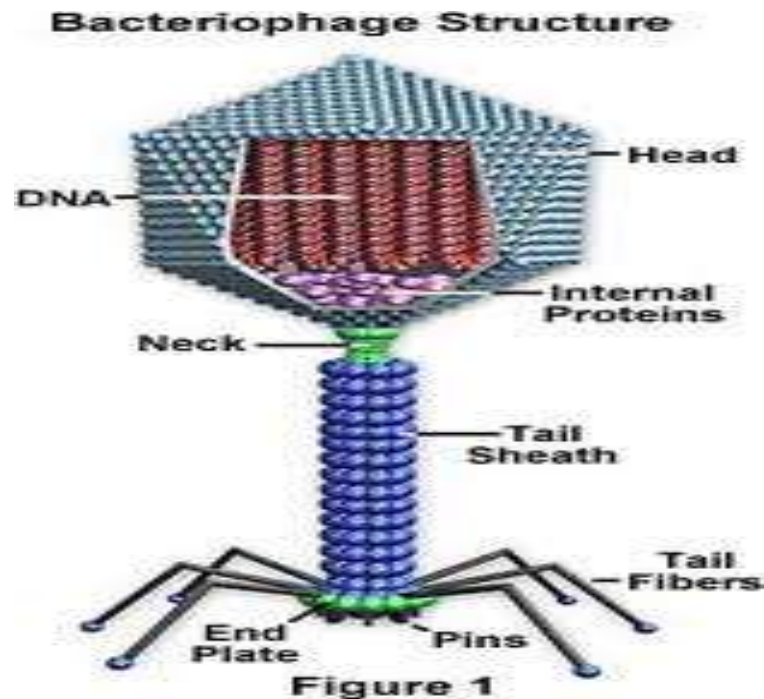


# Transduction

- Another method by which genetic recombination takes place in bacteria is Transduction.
- Genetic recombination in which a DNA fragment is transferred from one bacterium to another by a bacteriophage.

# What are Bacteriophages?

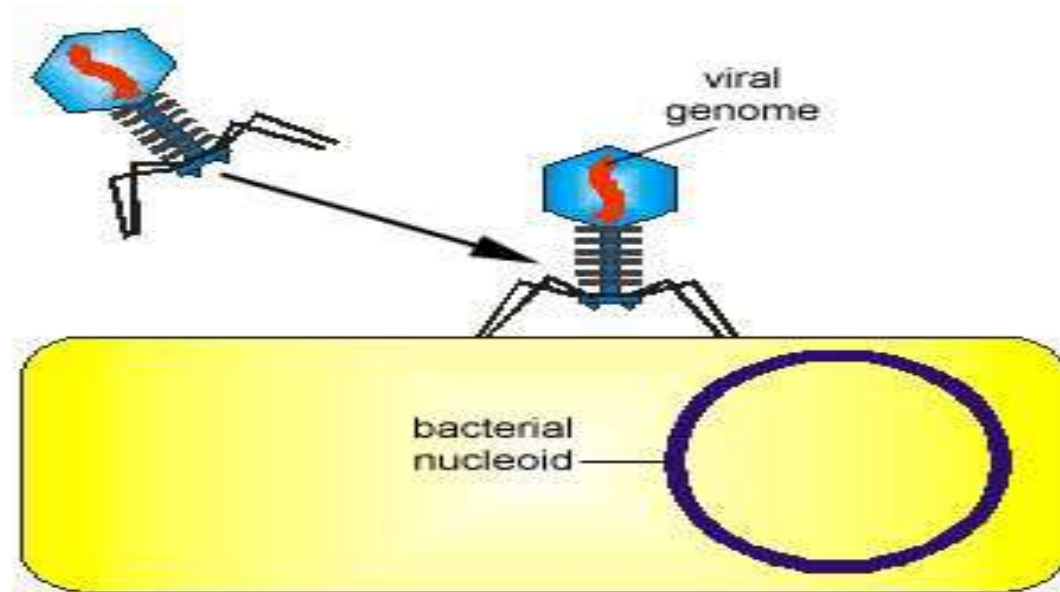
- Bacteriophage (phage) are obligate intracellular parasites that multiply inside bacteria by making use of some or all of the host biosynthetic machinery (i.e., viruses that infect bacteria).



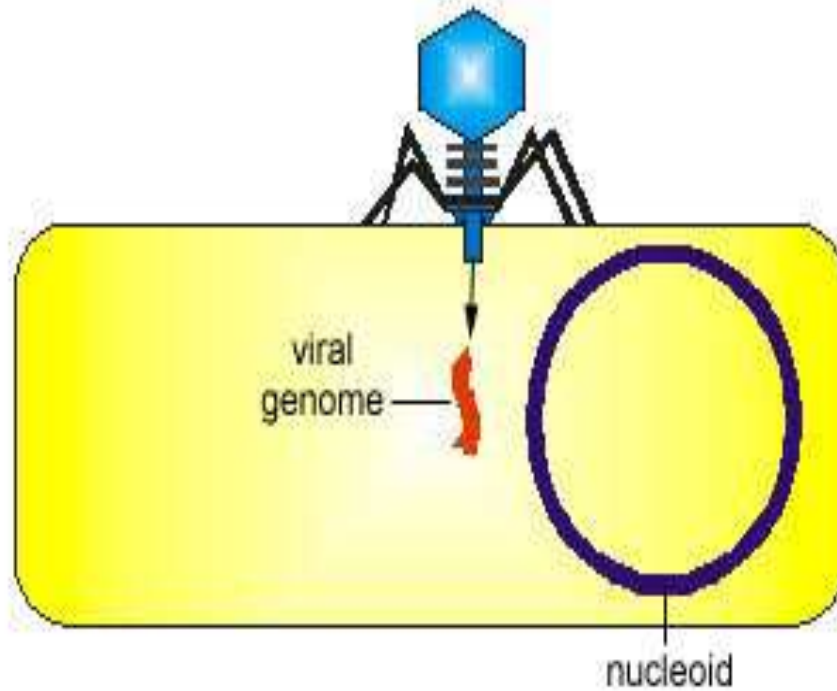
# Transduction (cont'd)

- There are two types of transduction:
  - **Generalized transduction:** A DNA fragment is transferred from one bacterium to another by a lytic bacteriophage that is now carrying donor bacterial DNA due to an error in maturation during the lytic life cycle.
  - **Specialized transduction:** A DNA fragment is transferred from one bacterium to another by a temperate bacteriophage that is now carrying donor bacterial DNA due to an error in spontaneous induction during the lysogenic life cycle

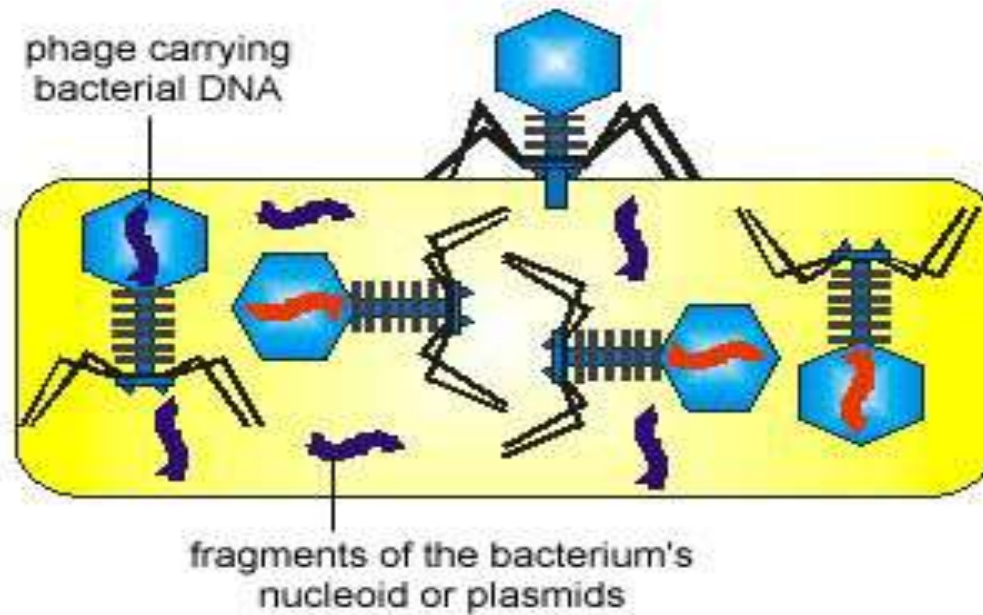
# Seven steps in Generalised Transduction



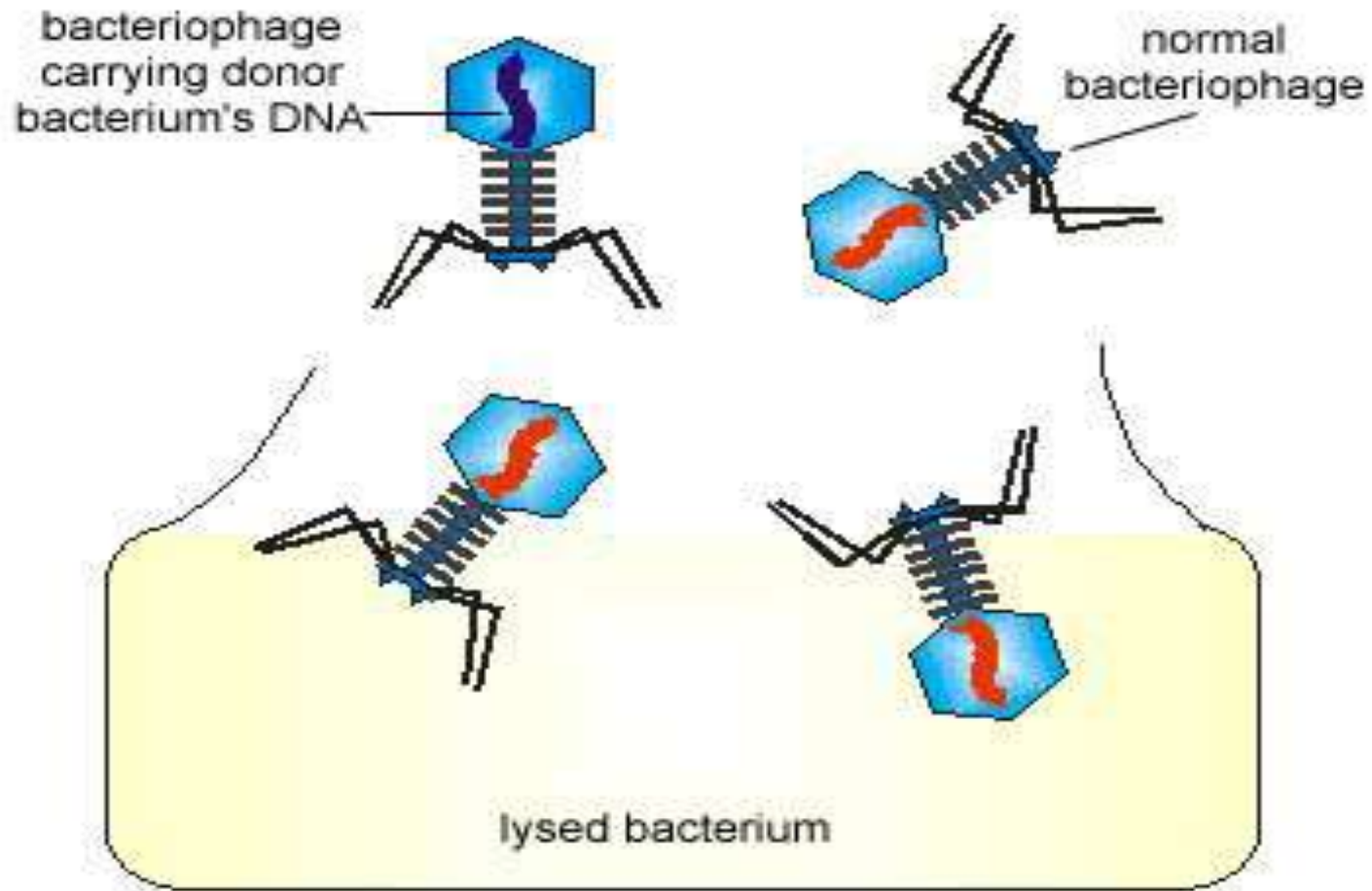
- 1.** A lytic bacteriophage adsorbs to a susceptible bacterium.



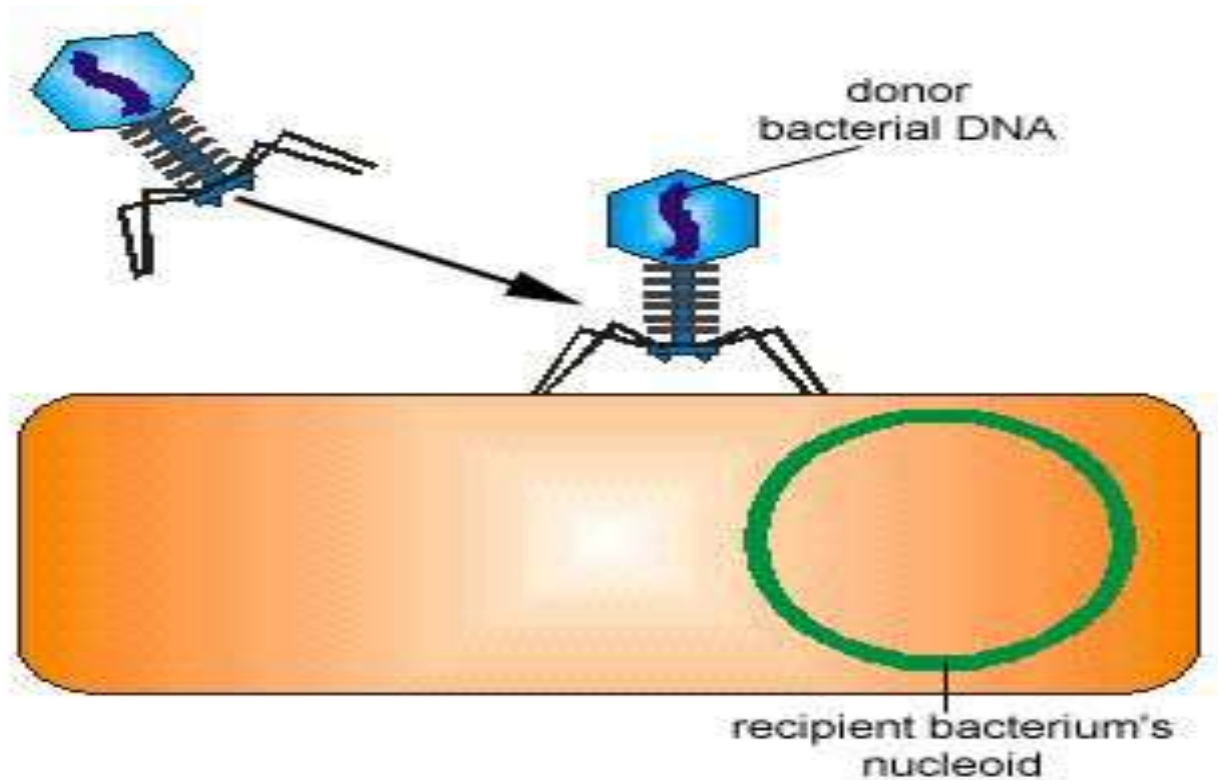
**2.** The bacteriophage genome enters the bacterium. The genome directs the bacterium's metabolic machinery to manufacture bacteriophage components and enzymes



**3.** Occasionally, a bacteriophage head or capsid assembles around a fragment of donor bacterium's nucleoid or around a plasmid instead of a phage genome by mistake.

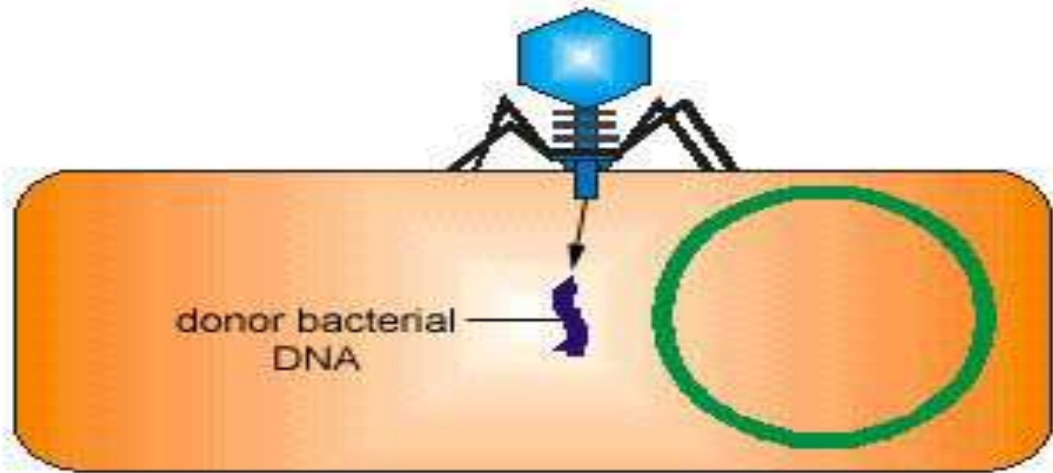


**4.** The bacteriophages are released.

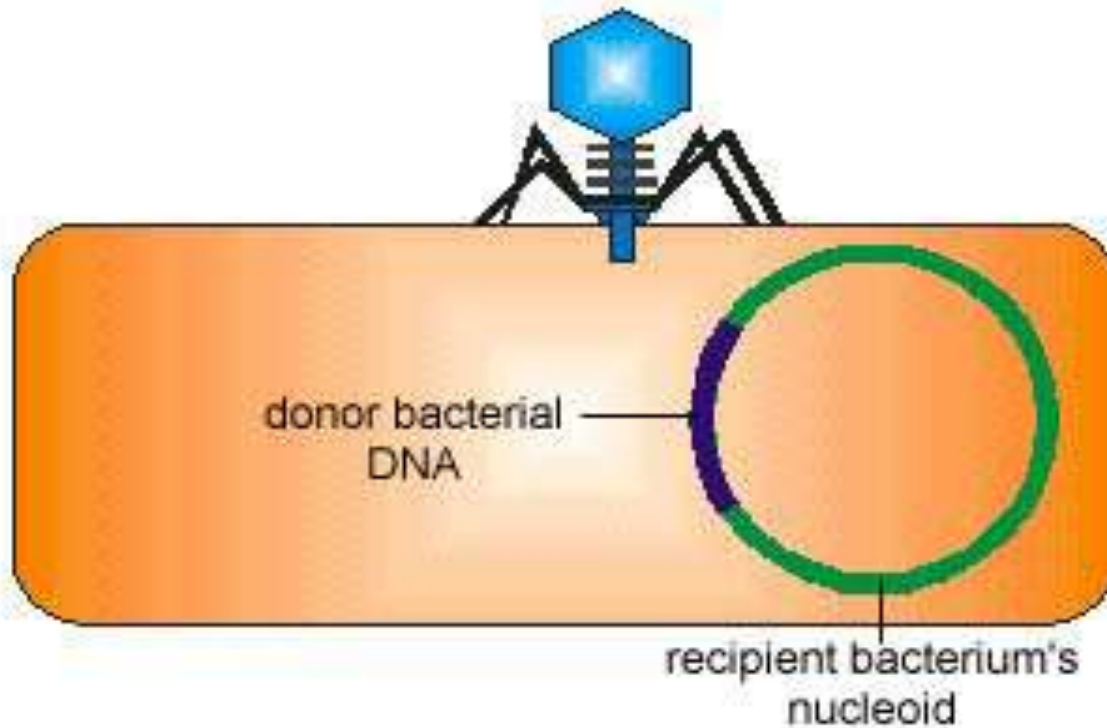


5. The bacteriophage carrying the donor bacterium's DNA adsorbs to a recipient bacterium



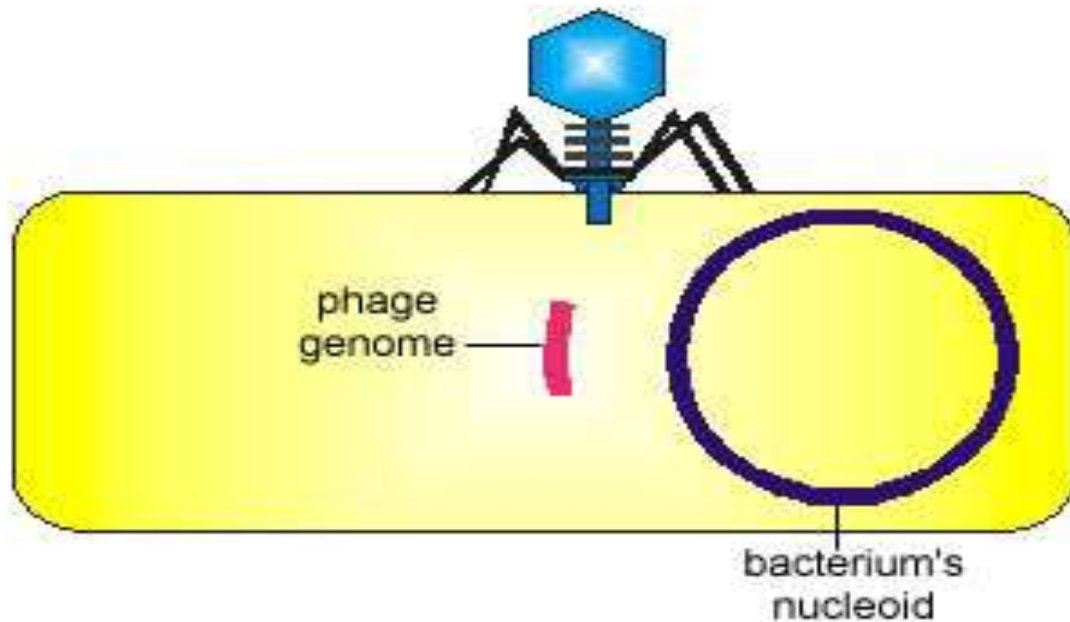


6. The bacteriophage inserts the donor bacterium's DNA it is carrying into the recipient bacterium .

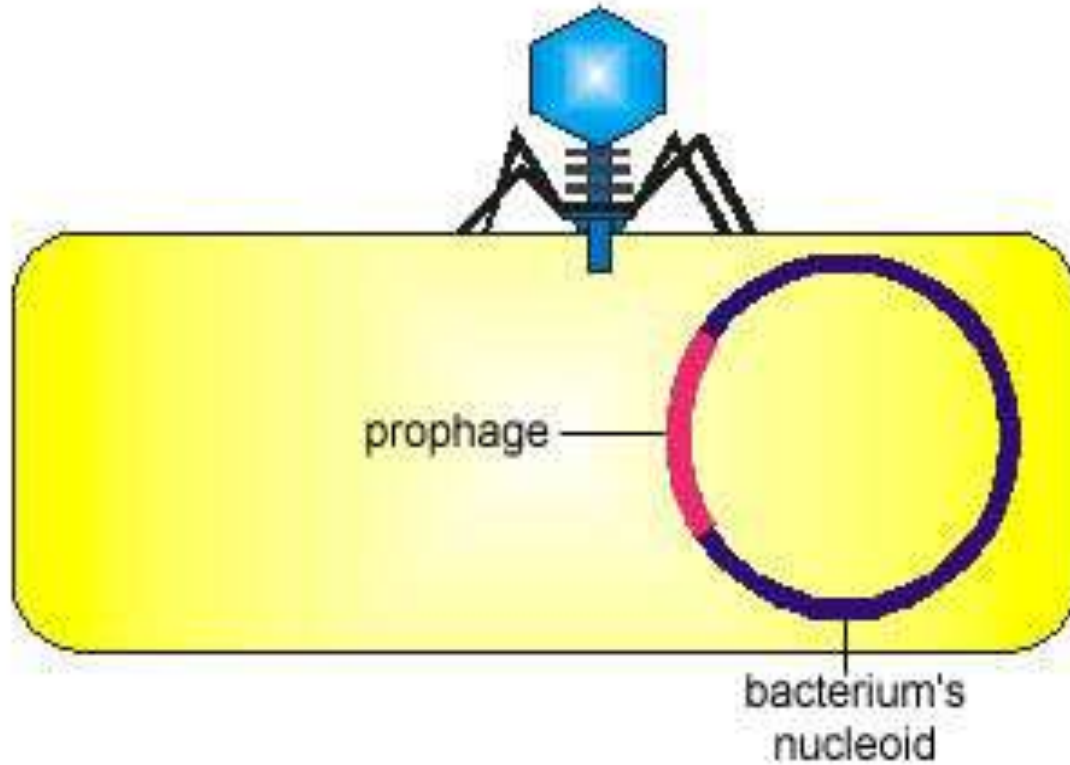


7. The donor bacterium's DNA is exchanged for some of the recipient's DNA.

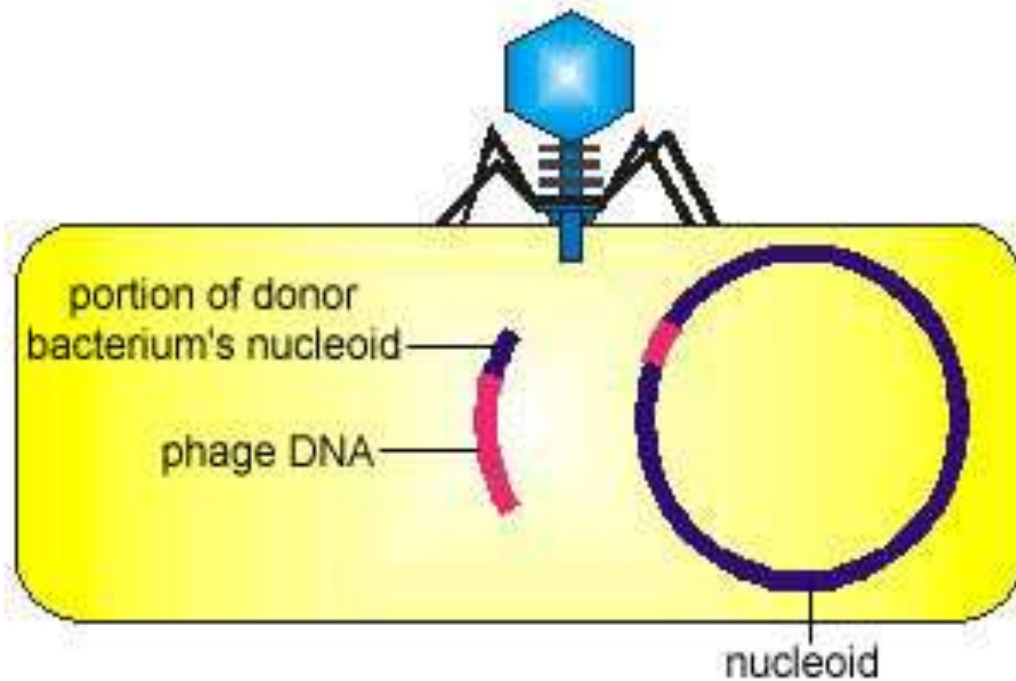
# Six steps in Specialised Transduction



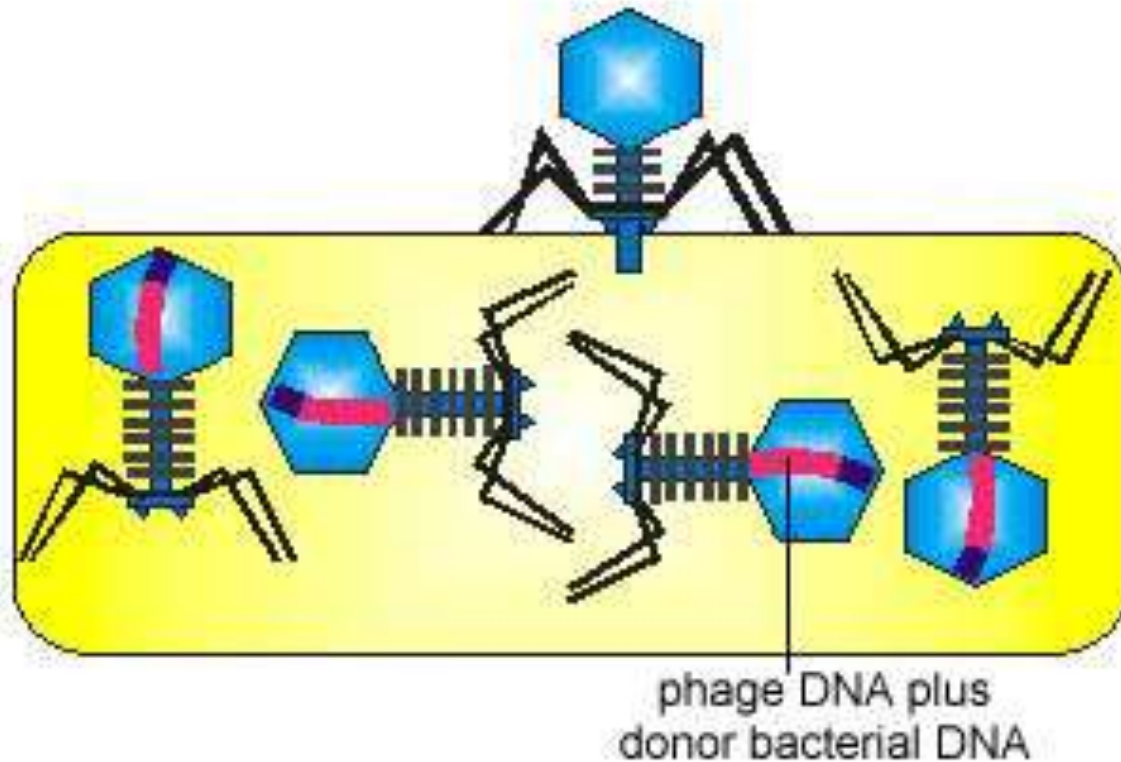
1. A temperate bacteriophage adsorbs to a susceptible bacterium and injects its genome .



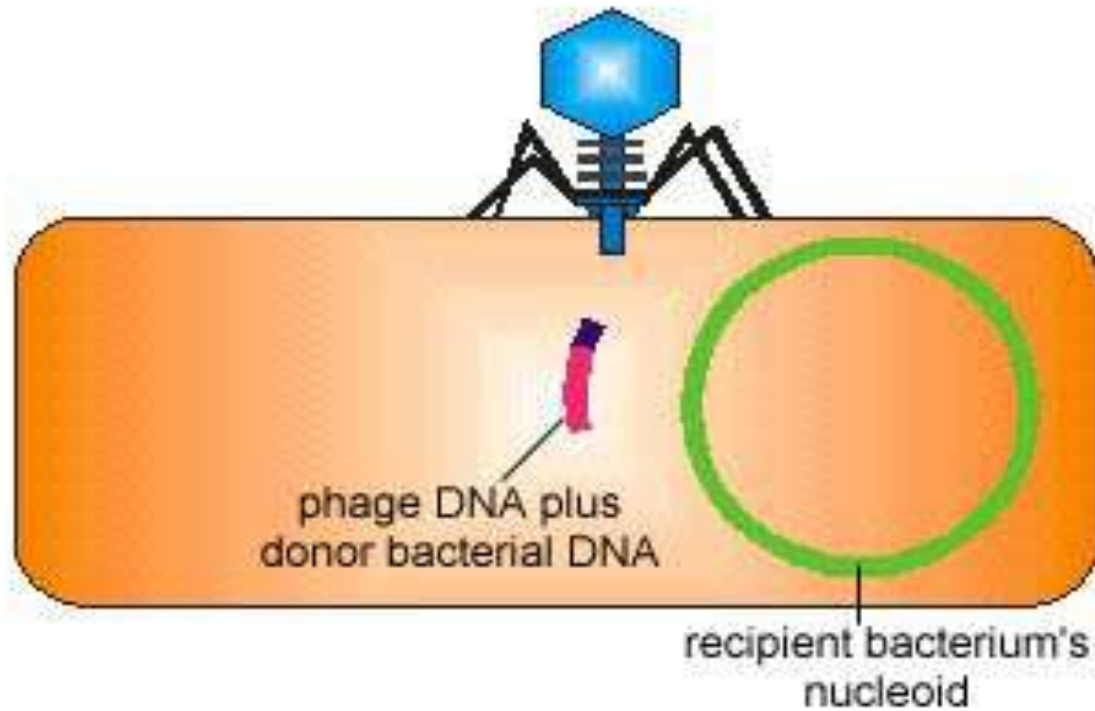
2. The bacteriophage inserts its genome into the bacterium's nucleoid to become a prophage.



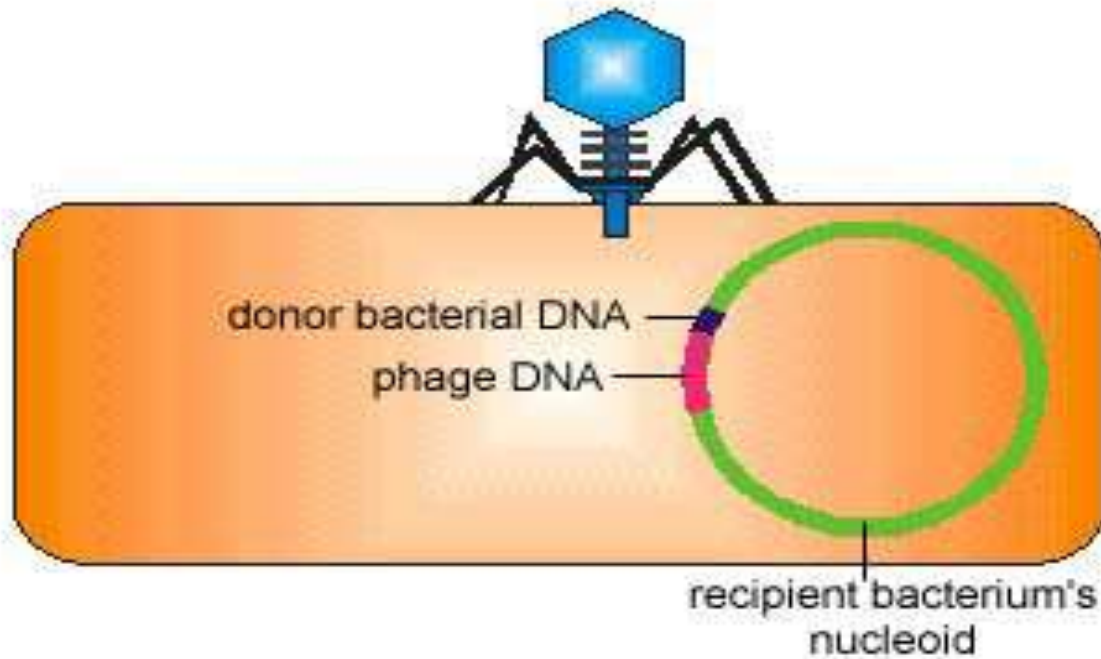
3. Occasionally during spontaneous induction, a small piece of the donor bacterium's DNA is picked up as part of the phage's genome in place of some of the phage DNA which remains in the bacterium's nucleoid.



4. As the bacteriophage replicates, the segment of bacterial DNA replicates as part of the phage's genome. Every phage now carries that segment of bacterial DNA.



5. The bacteriophage adsorbs to a recipient bacterium and injects its genome.



6. The bacteriophage genome carrying the donor bacterial DNA inserts into the recipient bacterium's nucleoid.



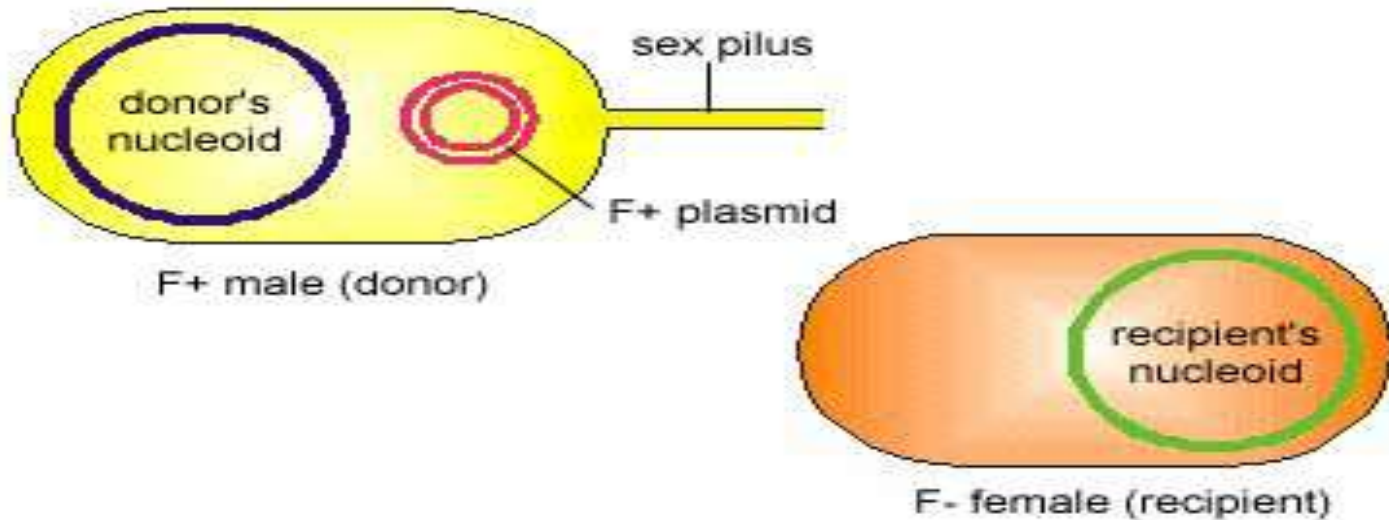
# Bacterial Conjugation

- Bacterial Conjugation is genetic recombination in which there is a transfer of DNA from a living donor bacterium to a recipient bacterium. Often involves a sex pilus.
- The 3 conjugative processes
  - I.  $F^+$  conjugation
  - II. Hfr conjugation
  - III. Resistance plasmid conjugation

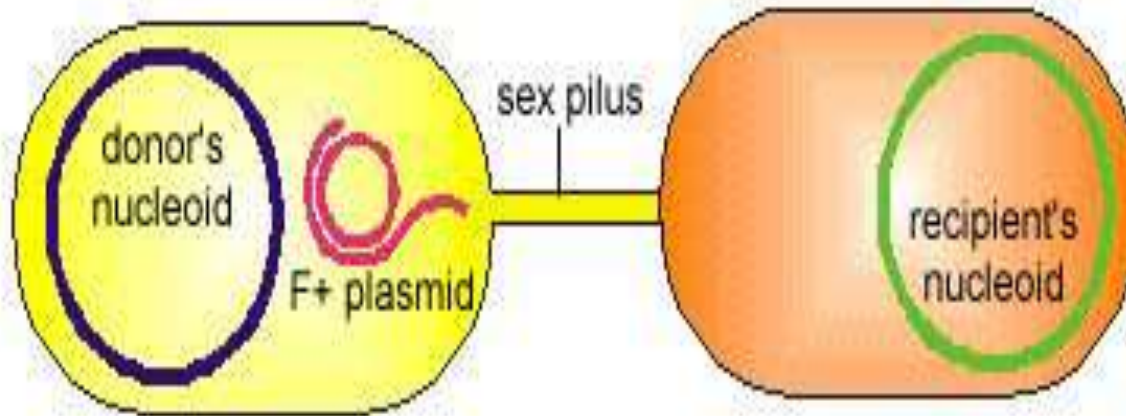
# I. F+ Conjugation Process

- F+ Conjugation- Genetic recombination in which there is a transfer of an F+ plasmid (coding only for a sex pilus) from a male donor bacterium to a female recipient bacterium.
- Doesn't include chromosomal DNA.
- Involves a sex (conjugation) pilus.
- Other plasmids present in the cytoplasm of the bacterium, such as those coding for antibiotic resistance, may also be transferred during this process.

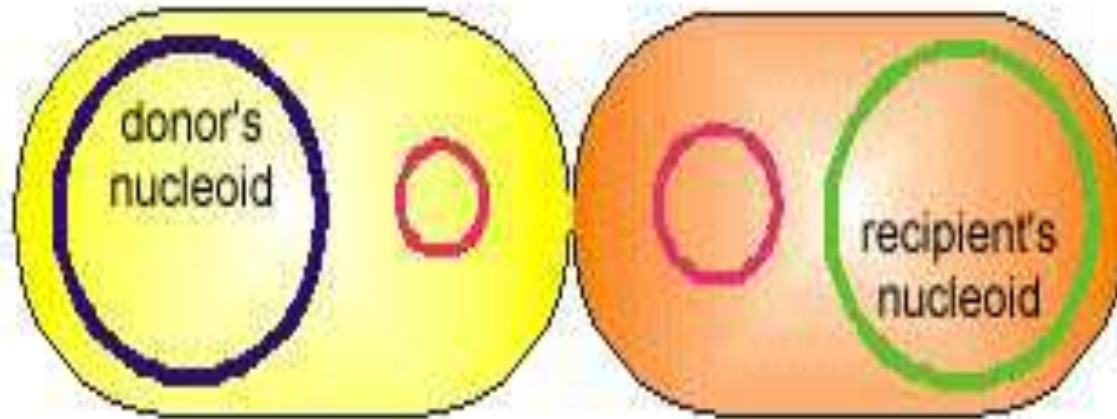
# The 4 stepped F+ Conjugation



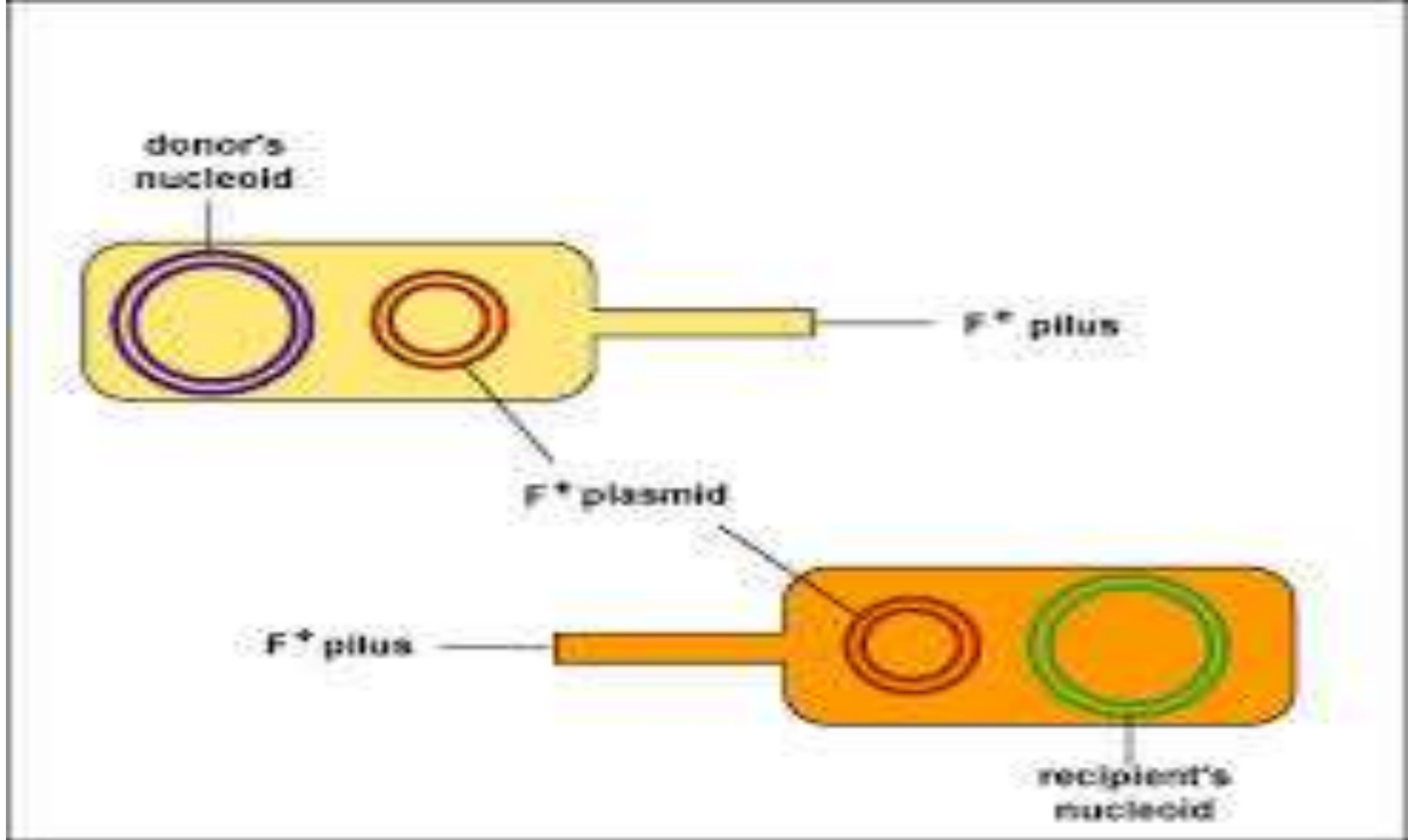
1. The F+ male has an F+ plasmid coding for a sex pilus and can serve as a genetic donor



2. The sex pilus adheres to an F- female (recipient).  
One strand of the F+ plasmid breaks



**3.** The sex pilus retracts and a bridge is created between the two bacteria. One strand of the F<sup>+</sup> plasmid enters the recipient bacterium

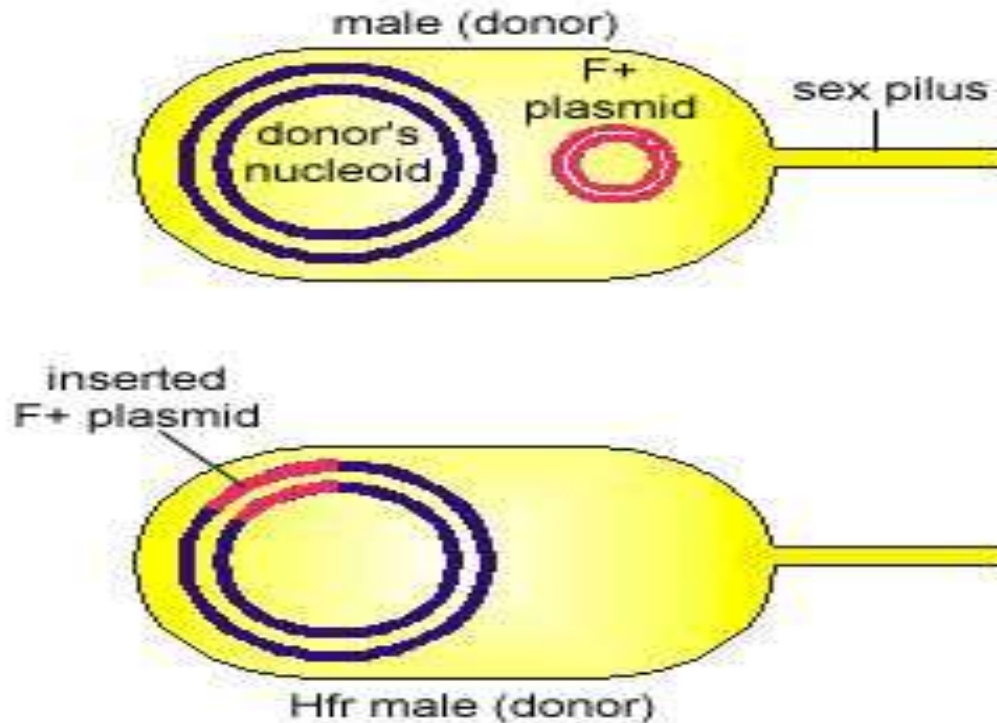


4. Both bacteria make a complementary strand of the F+ plasmid and both are now F+ males capable of producing a sex pilus. There was no transfer of donor chromosomal DNA although other plasmids the donor bacterium carries may also be transferred during F+ conjugation.

## II. Hfr Conjugation

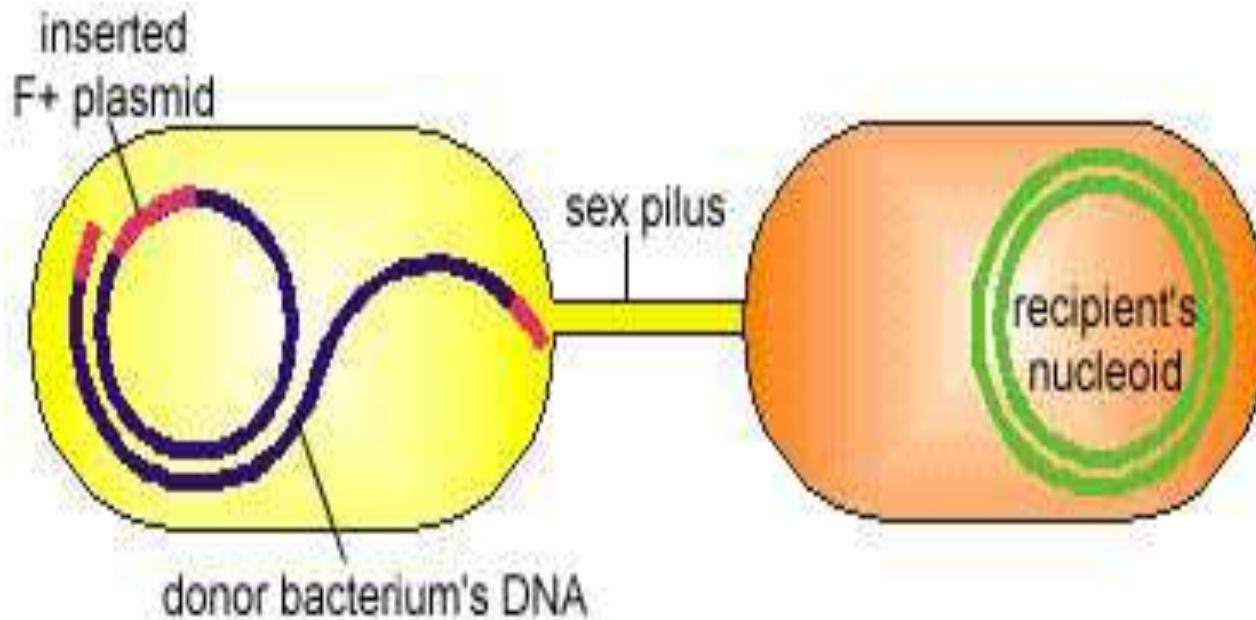
- Genetic recombination in which fragments of chromosomal DNA from a male donor bacterium are transferred to a female recipient bacterium following insertion of an F+ plasmid into the nucleoid of the donor bacterium.
- Involves a sex (conjugation) pilus.

# 5 stepped Hfr Conjugation

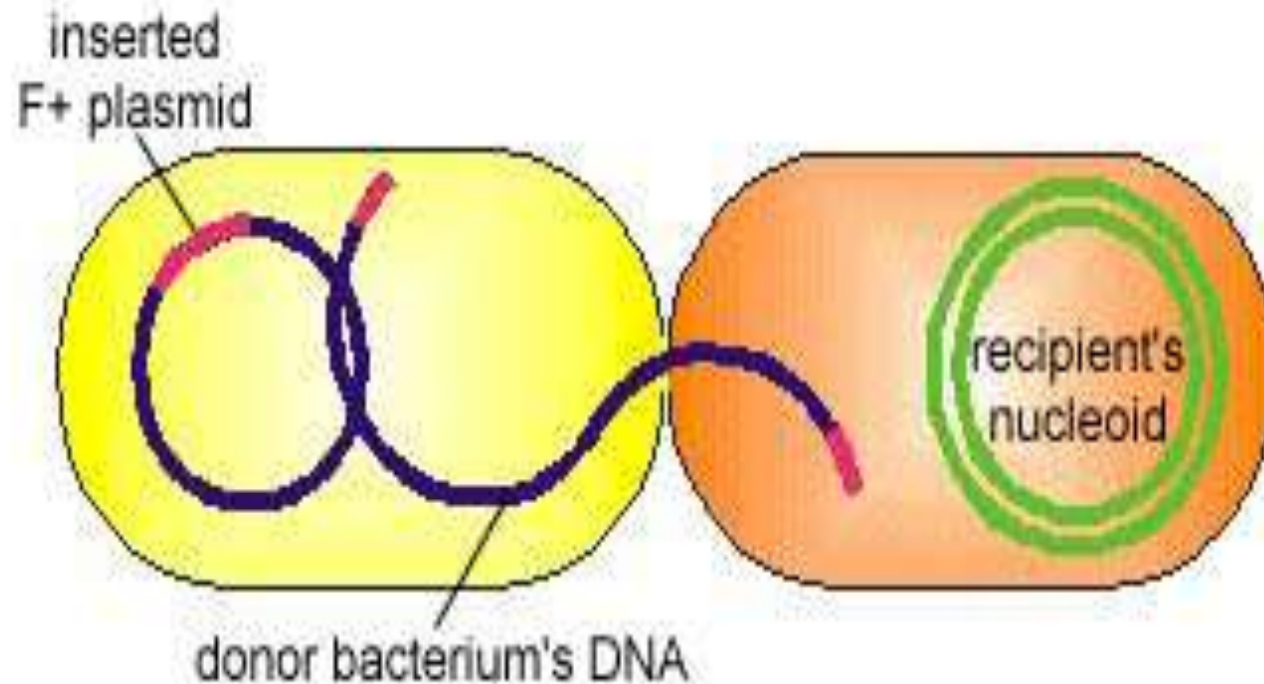


1. An F+ plasmid inserts into the donor bacterium's nucleoid to form an Hfr male.

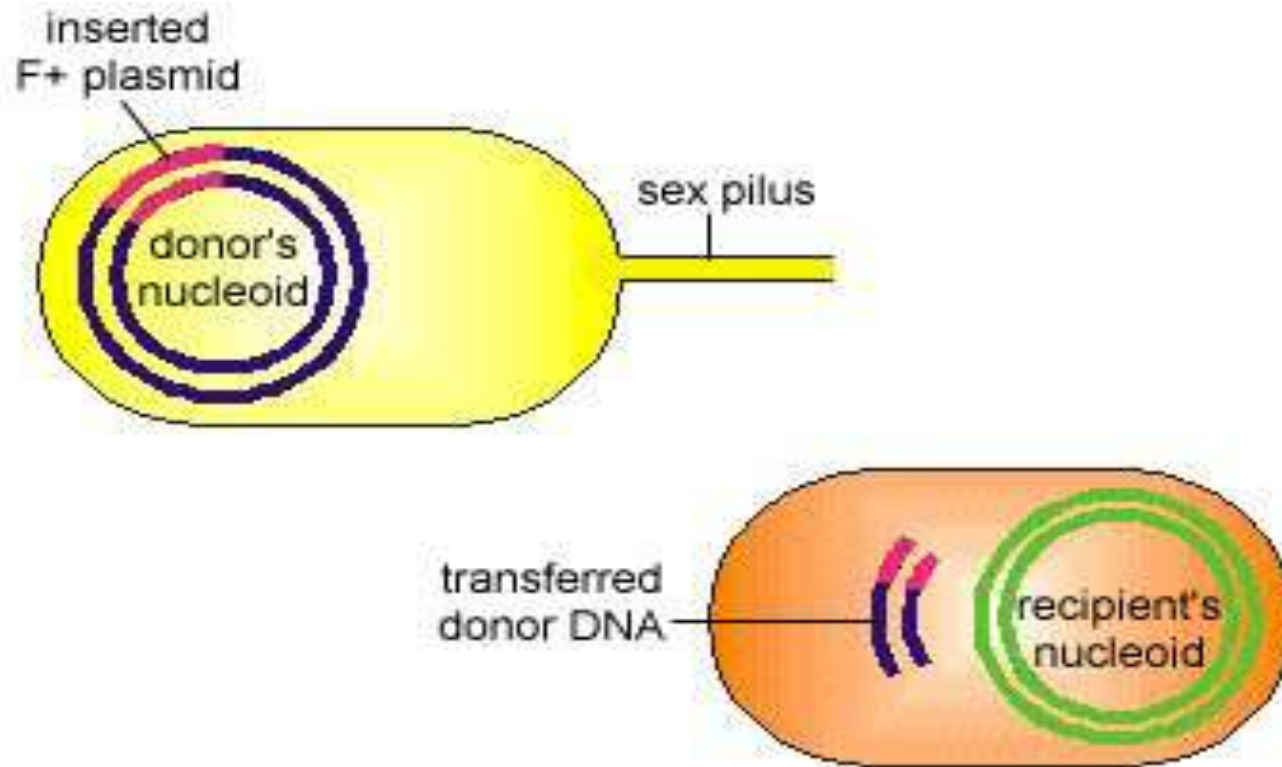




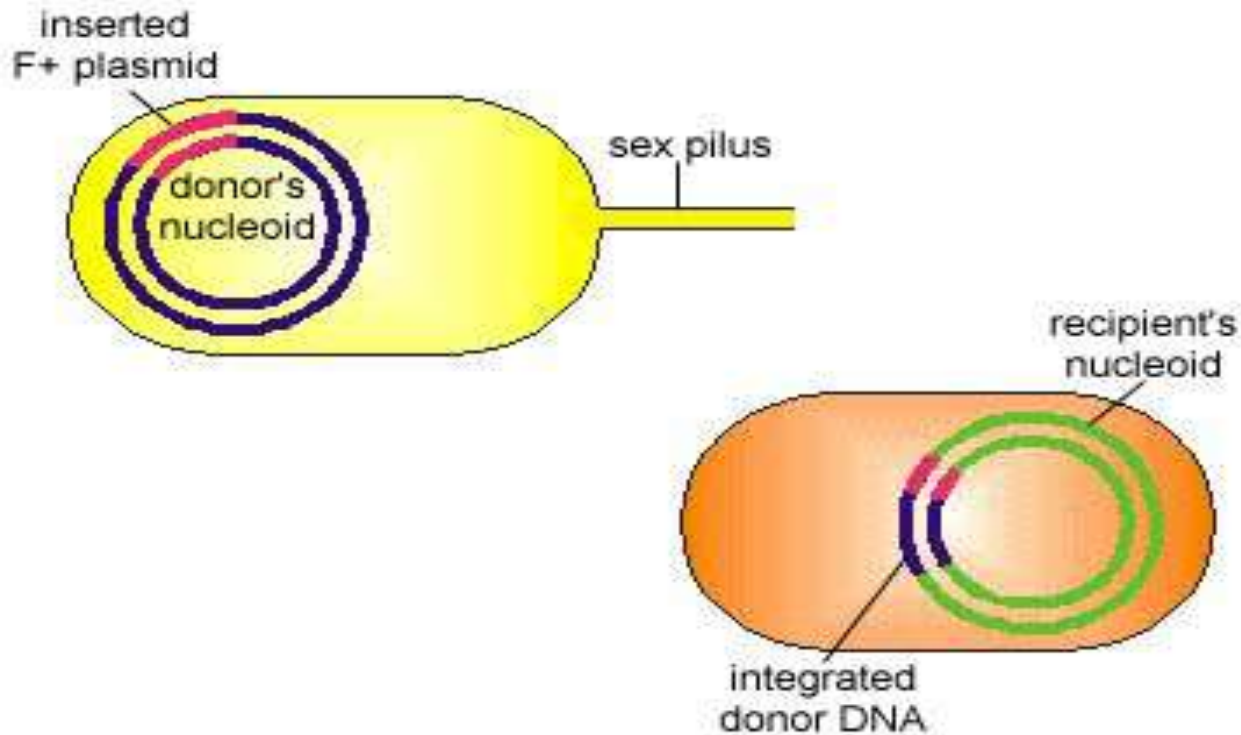
**2.** The sex pilus adheres to an F- female (recipient). One donor DNA strand breaks in the middle of the inserted F+ plasmid.



**3.** The sex pilus retracts and a bridge forms between the two bacteria. One donor DNA strand begins to enter the recipient bacterium. The two cells break apart easily so the only a portion of the donor's DNA strand is usually transferred to the recipient bacterium.



4. The donor bacterium makes a complementary copy of the remaining DNA strand and remains an Hfr male. The recipient bacterium makes a complementary strand of the transferred donor DNA.

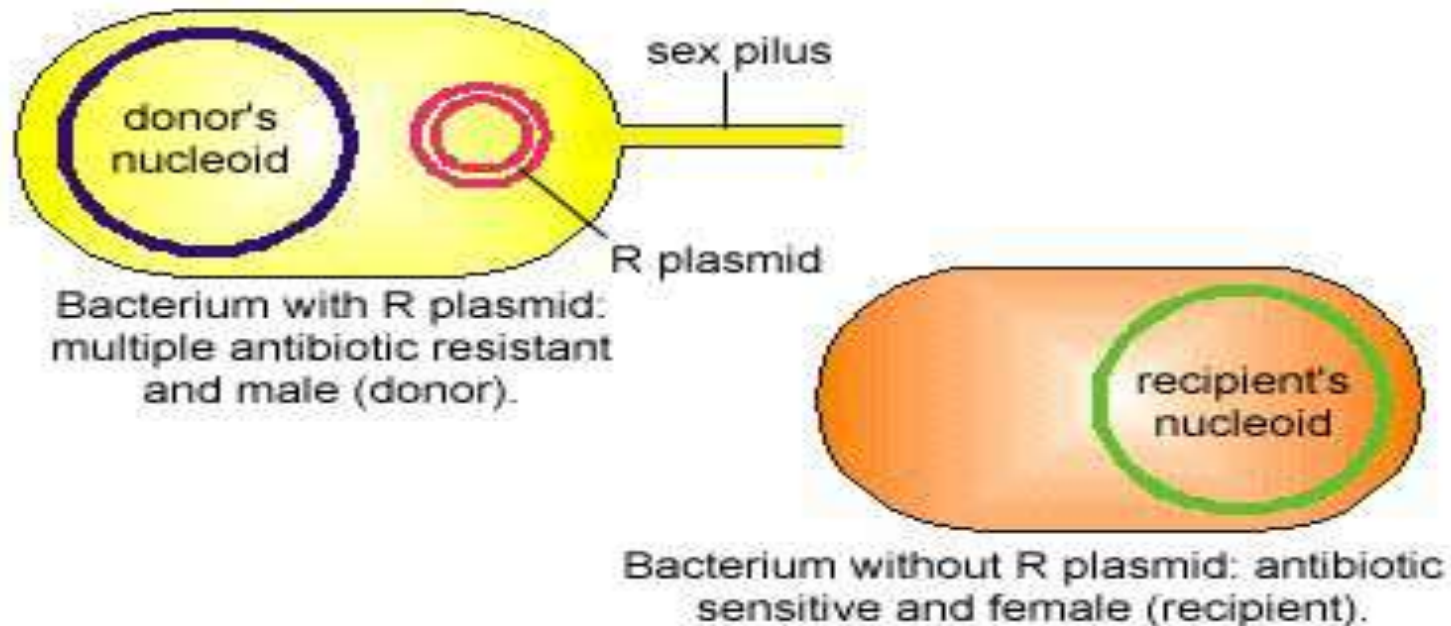


5. The donor DNA fragment undergoes genetic exchange with the recipient bacterium's DNA. Since there was transfer of some donor chromosomal DNA but usually not a complete F+ plasmid, the recipient bacterium usually remains F-

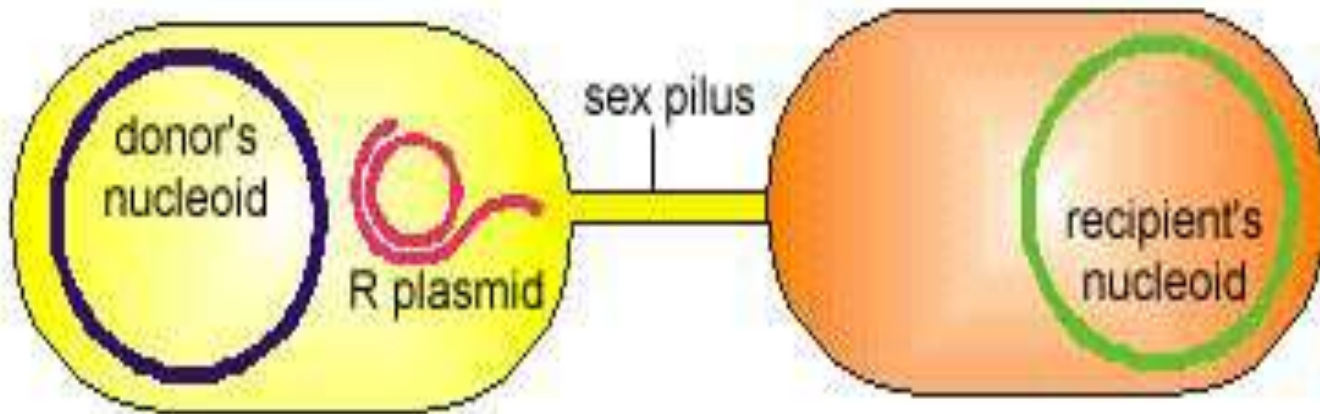
### III. RESISTANT PLASMID CONJUGATION

- Genetic recombination in which there is a transfer of an R plasmid (a plasmid coding for multiple antibiotic resistance and often a sex pilus) from a male donor bacterium to a female recipient bacterium.
- Involves a sex (conjugation) pilus

# 4 Stepped Resistant Plasmid Conjugation

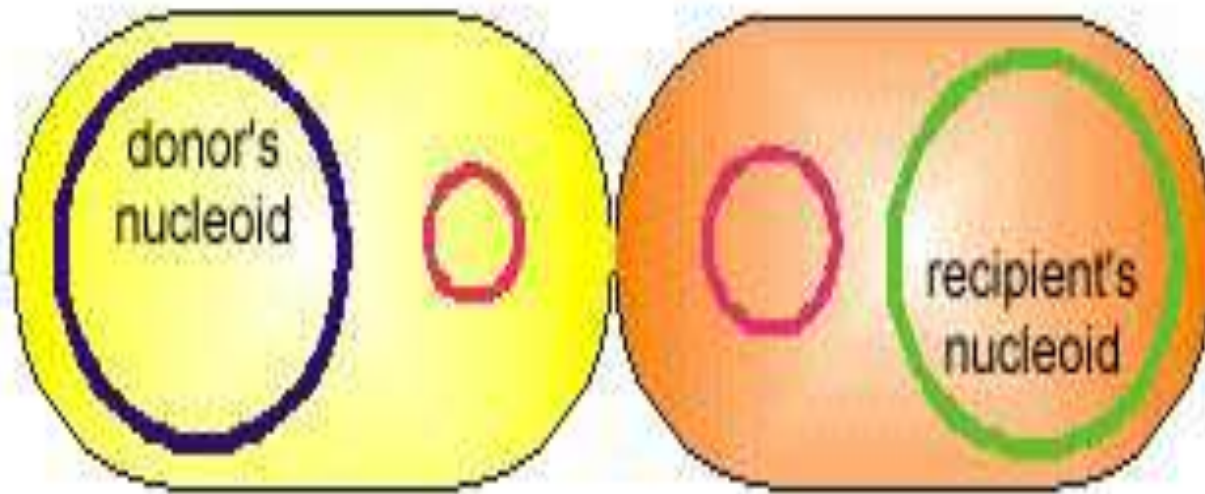


1. The bacterium with an R-plasmid is multiple antibiotic resistant and can produce a sex pilus (serve as a genetic donor).



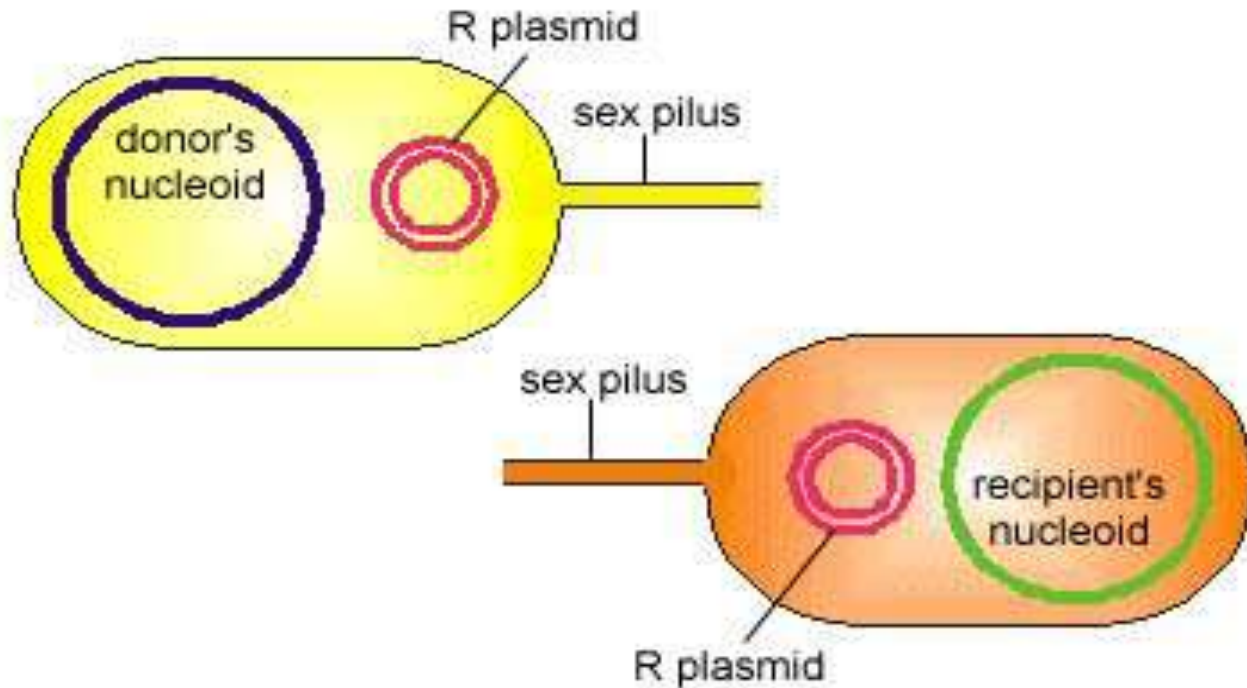
2. The sex pilus adheres to an F- female (recipient). One strand of the R-plasmid breaks.





3. The sex pilus retracts and a bridge is created between the two bacteria. One strand of the R-plasmid enters the recipient bacterium.

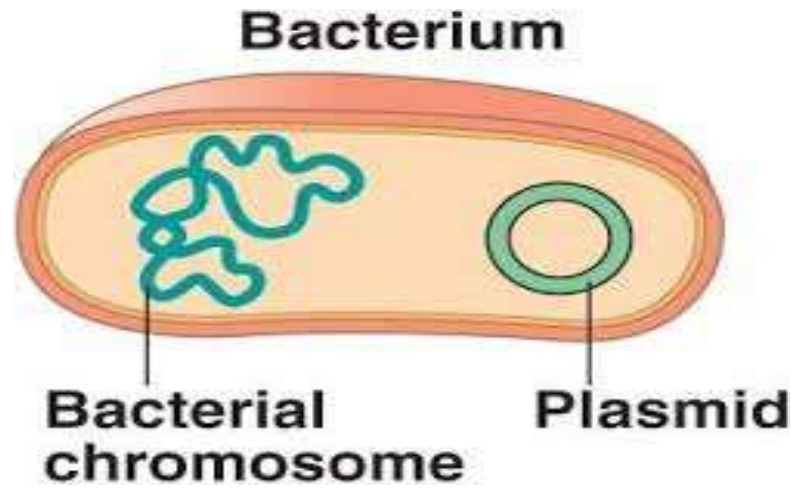




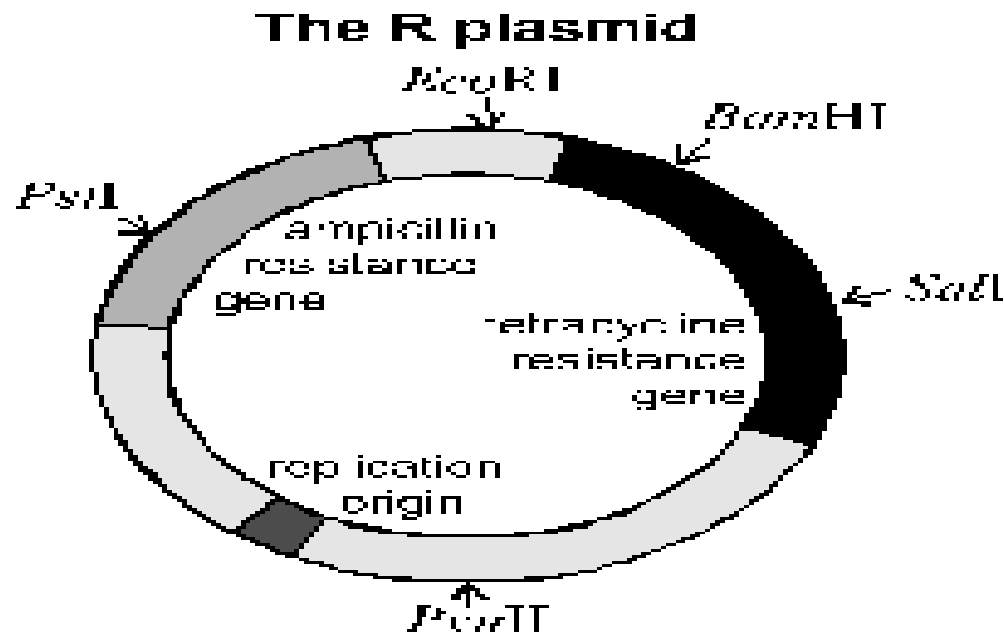
4. Both bacteria make a complementary strand of the R-plasmid and both are now multiple antibiotic resistant and capable of producing a sex pilus.

# PLASMIDS

- A **plasmid** is a small DNA molecule within a cell that is physically separated from a chromosomal DNA and can replicate independently.



- Plasmids carry genes that may benefit survival of the organism (e.g. antibiotic resistance), and can frequently be transmitted from one bacterium to another (even of another species) via horizontal gene transfer.
- Plasmids usually are very small and contain additional information.



# TYPES OF PLASMIDS

Plasmids are classified :

➤ By their ability to be transferred to other bacteria:

## 1 . Conjugative plasmids

- The **sexual transfer** of plasmids to another bacterium through a pilus.

## 2 . Non-conjugative :

- Non-conjugative plasmids don't initiate conjugation
- Only be transferred with the help of conjugative plasmids

## 3 . Mobilisable

- Intermediate class of plasmids
- Mobilizable, and carry only a subset of the genes required for transfer.
- Can 'parasitise' another plasmid, transferring at high frequency in the presence of a conjugative plasmid.

## 2. By function

### 1. Fertility-(F) plasmids,

They are capable of conjugation (they contains the genes for the pili).

### 2. Resistance-(R) plasmids,

Contain gene (s) that can build resistance against one or several antibiotics or poisons.

### 3. Col-plasmids,

Contain genes coding for colicines, proteins that can kill other bacteria.

### 4. Degradative plasmids,

Able to digest unusual substances, e.g., toluene or salicylic acid.

### 5. Virulence plasmids,

Turn a bacterium into a pathogen.

# EPISOMES

- An episome is a portion of genetic material that can exist independent of the chromosome at some times, while at other times is able to integrate into the chromosome.
- Examples of episomes include :
  - Insertion sequences and transposons.
  - Viruses
  - F factor

# 1. Transposons and insertion sequence

- Transposons and insertion sequences are episomes.
- Also known as mobile genetic elements.
- Capable of existing outside of the chromosome.
- Also designed to integrate into the chromosome and then move from one cell to another.
- Transposons can carry other genetic material with them.



## 2. Viruses

- Viruses are another example of an episome.
- Viruses will integrate their genetic material into the host chromosome.

## 3. F factor

- F factor that has integrated into the host chromosome is known as Hfr.
- Hfr stands for high frequency of recombination.

# IN SUMMARY

**BACTERIAL RECOMBINATION** occurs in 3 ways

- Transformation
- Transduction
- Recombination

## **PLASMIDS :**

Autonomously replicating extra chromosomal DNA

## **EPISOMES:**

Piece of genetic material capable of existing independent of chromosome as well as in integrated form.

**THANK YOU**