

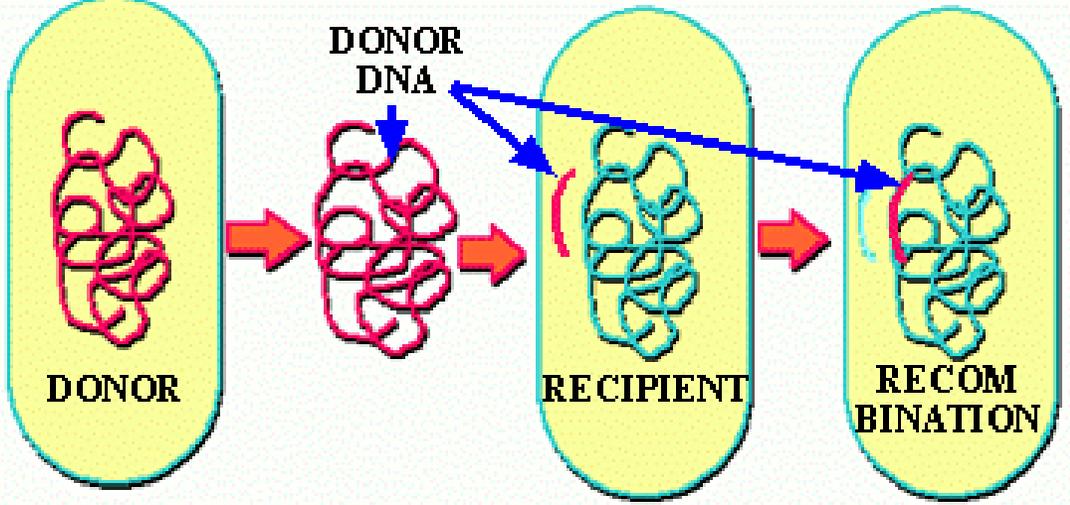
# **Week 11. Transfer of Genetic Material in Bacteria**

# **TRANSFER OF GENETIC MATERIAL IN BACTERIA**

**Department of Microbiology**

# Things to know...

- Donor bacteria (bacterium giving the genetic material),
- Recipient bacteria (Bacteria receiving the genetic material)
- Transfer could be both *in-vitro* and *in-vivo*
- Fusion with the recipient's chromosome: genetic homogeneity of bacteria (homology between DNA sequences of donor&recipient bacteria)
- The recipient bacteria can become positive in terms of the special characters carried by the gene/genes in the foreign DNA sequence integrated into its own chromosome.



# **Transfer of Genetic Material Between Bacteria (Natural Gene Transfer)**

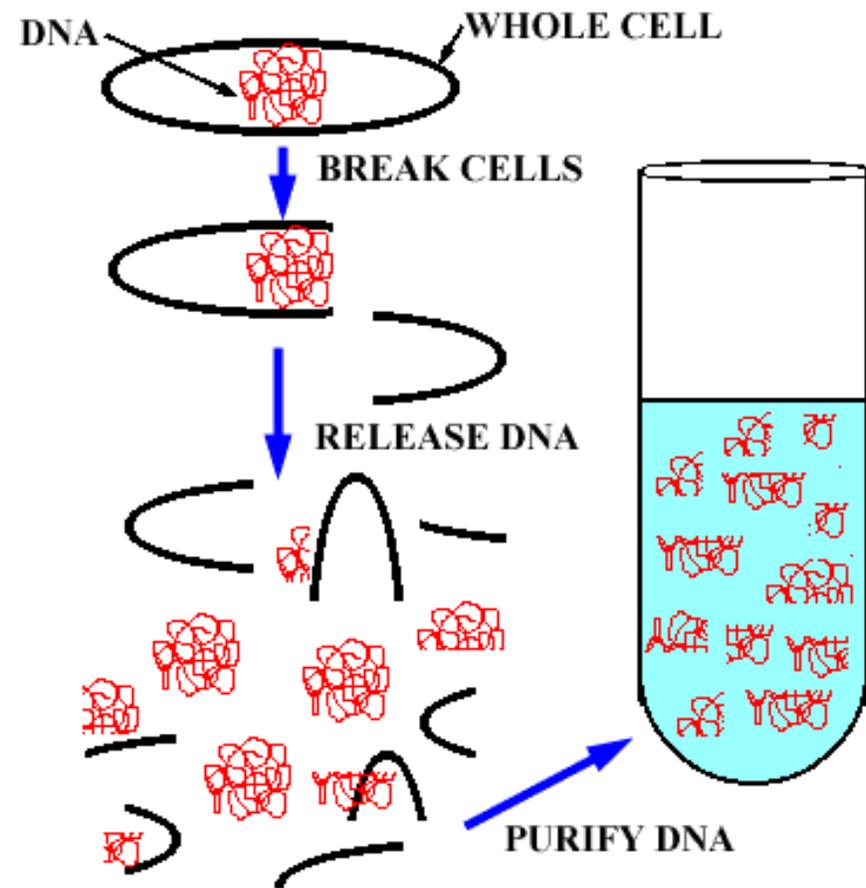
- 1. Transformation**
- 2. Conjugation**
- 3. Transduction**

# 1. TRANSFORMATION

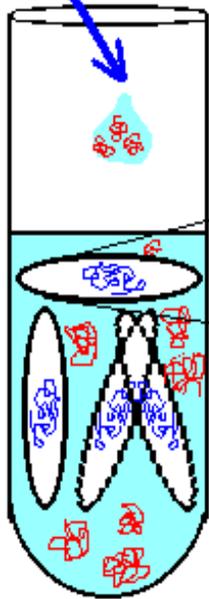
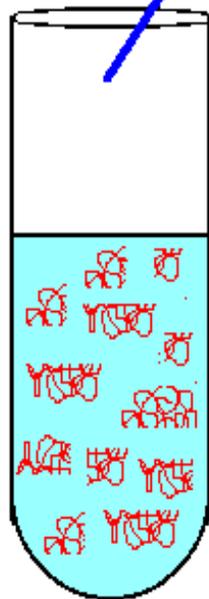
- Two microorganisms whose DNA composition is identical/similar to with each other
- If one of these microorganism is produced in a medium containing genetic material from the other, the donor microorganism;
- The recepiant microorganism can take donor's genetic material and show its physical characteristics...

# *In-vitro* Transformation

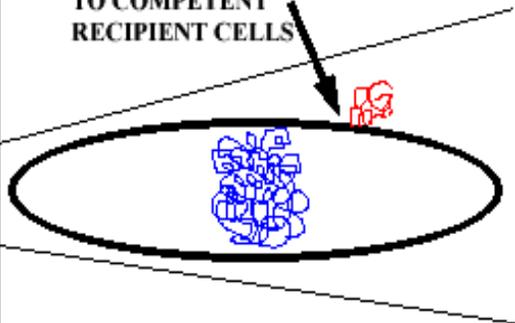
- *Trials with II-S and II-R strains of **Diplococcus pneumoniae***
- *II-S was inactivated (killed) and its DNA extracts were included into the medium.*
- *The living II-R strain received the genetic materials of the II-S strain from the medium and became positive in terms of the characteristics carried in these genetic elements (transformed into II-S).*

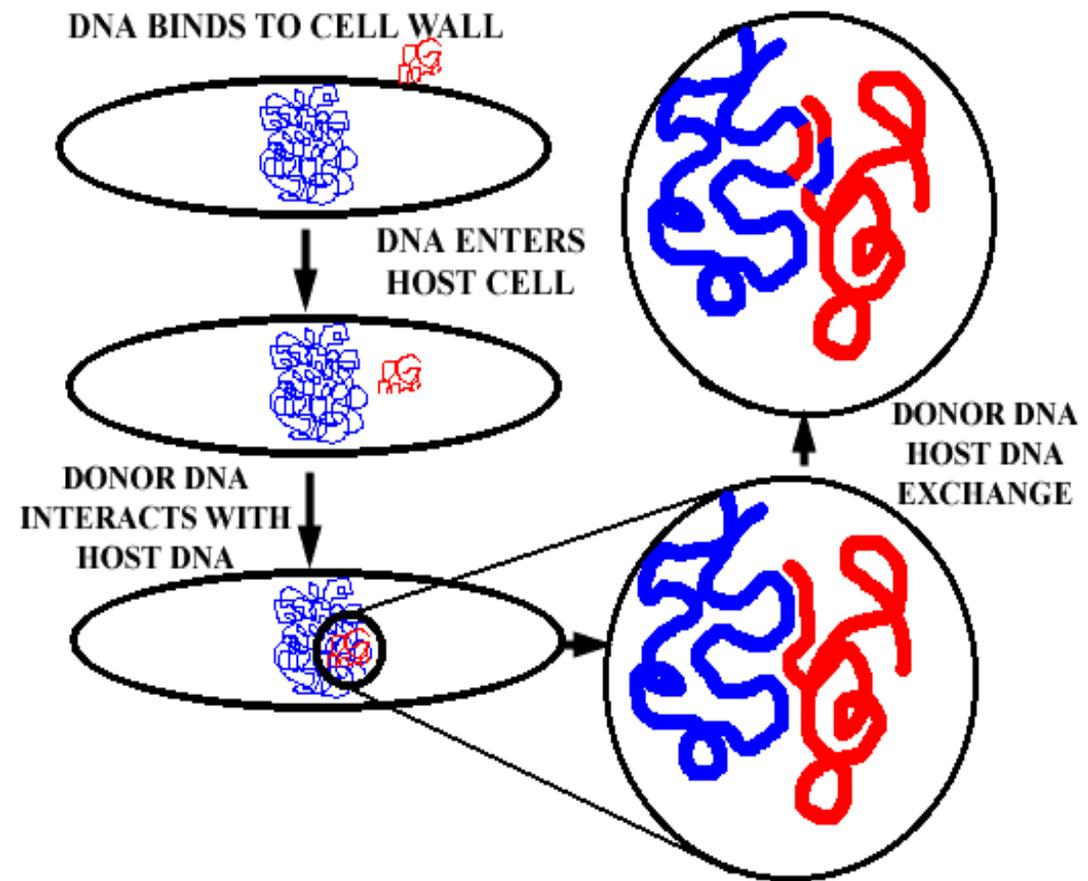


TRANSFER  
DONOR DNA INTO  
COMPETENT  
RECIPIENT CELLS



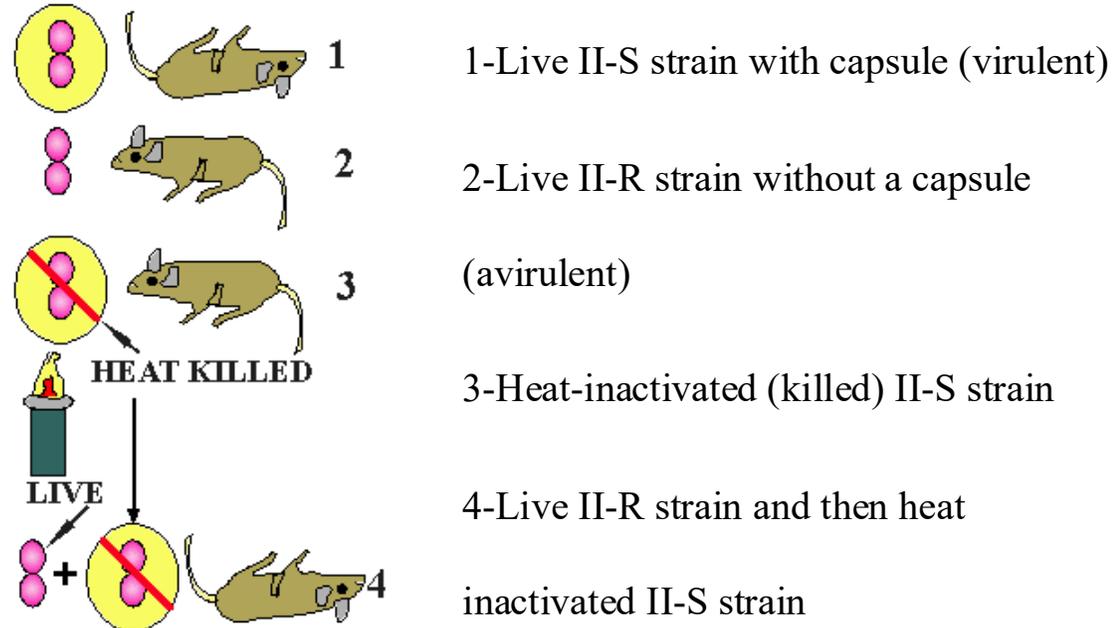
DONOR DNA BINDS  
TO COMPETENT  
RECIPIENT CELLS





# *In-vivo* Transformation

- Griffith Experiment



# Conditions required for transformation

- Presence of antigenic similarity in bacteria
- Homology between their DNA
- The recipient cell is competent (capable of taking up a piece of DNA and/or permeability)
- Molecular weight (at least  $0.3-8 \times 10^5$  daltons) and structure (double-stranded) of DNA
- Presence of receptors required for adsorption and penetration on the surface of the recipient cell

- The time between the DNA segment adsorbing on the recipient cell surface and joining with the competent DNA after it enters the cell is called the eclipse (latent) period.
- DNA fragment entering from outside to inside the cell is exogenot
- Fusion of recipient cell DNA with endogenot is recombination

# With Transformation;

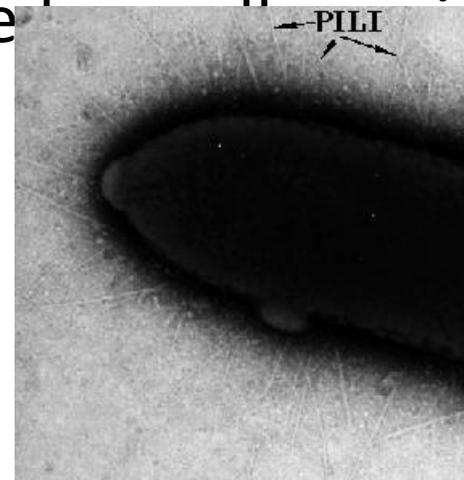
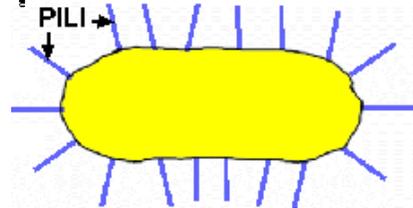
- Lactose and galactose positive genes,
- Resistance to antibacterial agents,
- Transfer of various virulence genes to recipient bacteria,
- Determination of chromosome maps of bacteria

# Transfection

- Transfer of phage DNA (or plasmid) into a competent bacterial cell

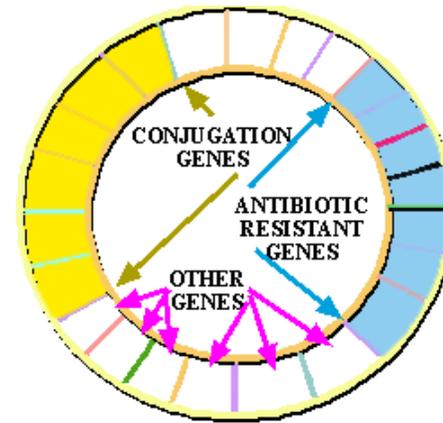
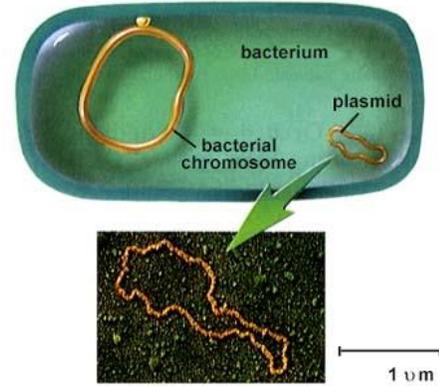
## 2. CONJUGATION

- The transfer of all or a fragment of the donor cell's DNA to the recipient by direct contact of these sex pili

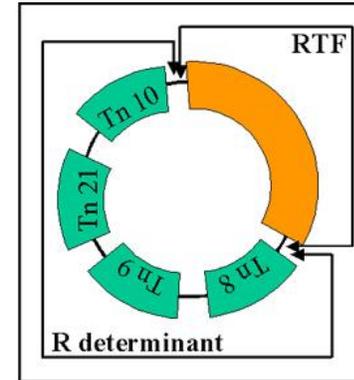
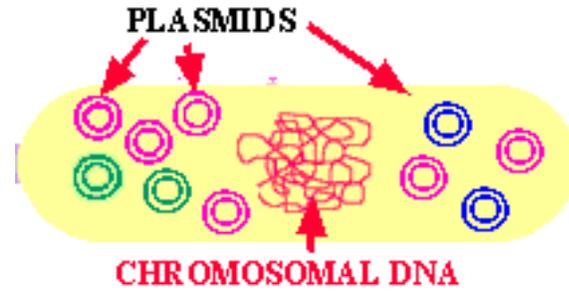


# For Conjugation;

- Direct contact
- *The ability to be a donor is determined by plasmids (transfer factor or sex factor), which is a transmissible genetic element in the cell.*
- *Cells that receive this factor become positive for transported characteristics.*
- *The sex pilus (fimbria) is synthesized by special genes in the sex factor (plasmid) inside the cell*



**CIRCULAR PLASMID DNA**



## Extrachromosomal genetic elements that can be transferred by conjugation

- Fertility factor (F-factor)
- Resistancy factors (R-factors)
- Colisin factor (Col-factor)
  
- Cells with an F factor on the chromosome (Hfr, high frequency recombination) have a higher F+ transmission frequency than cells with an independent F factor.

# F factor

- circular, double-stranded DNA segment
- 32 nm long (1.2% of bacterial DNA)
- can encode 40-60 proteins

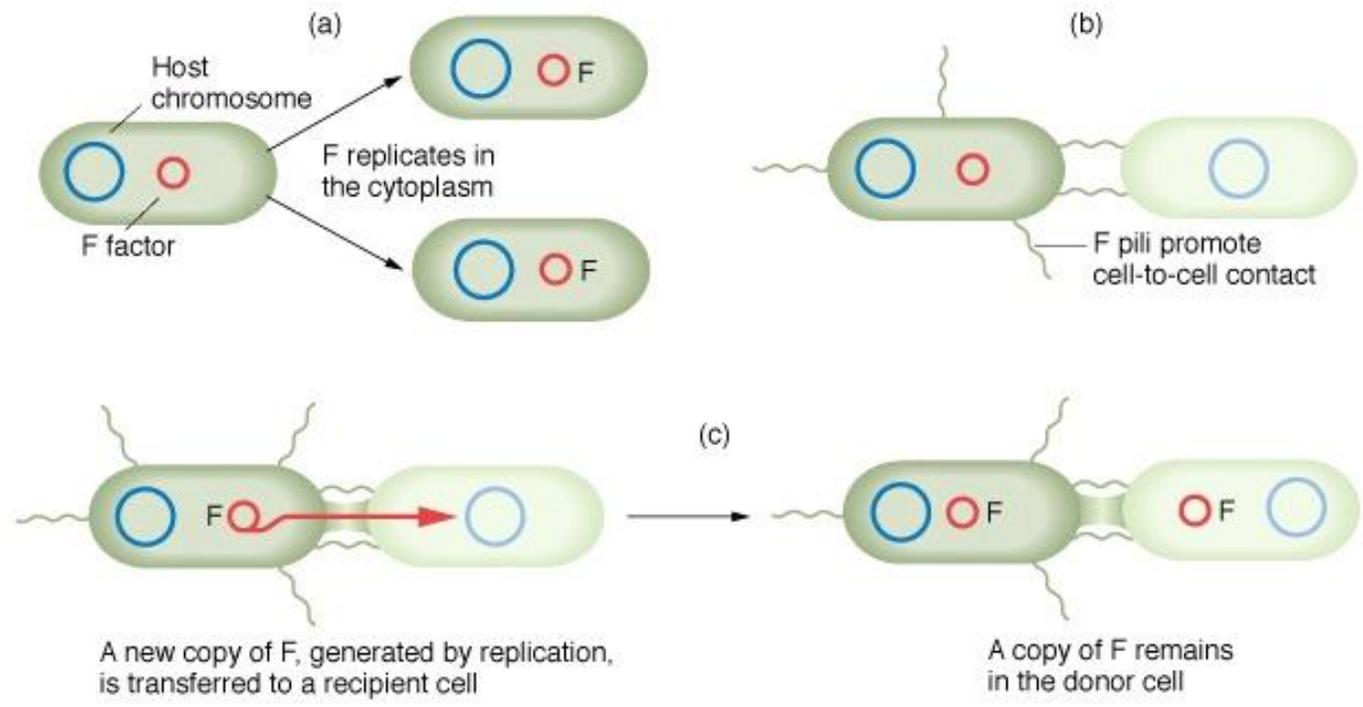
## F factor can be found in 3 different forms in a cell

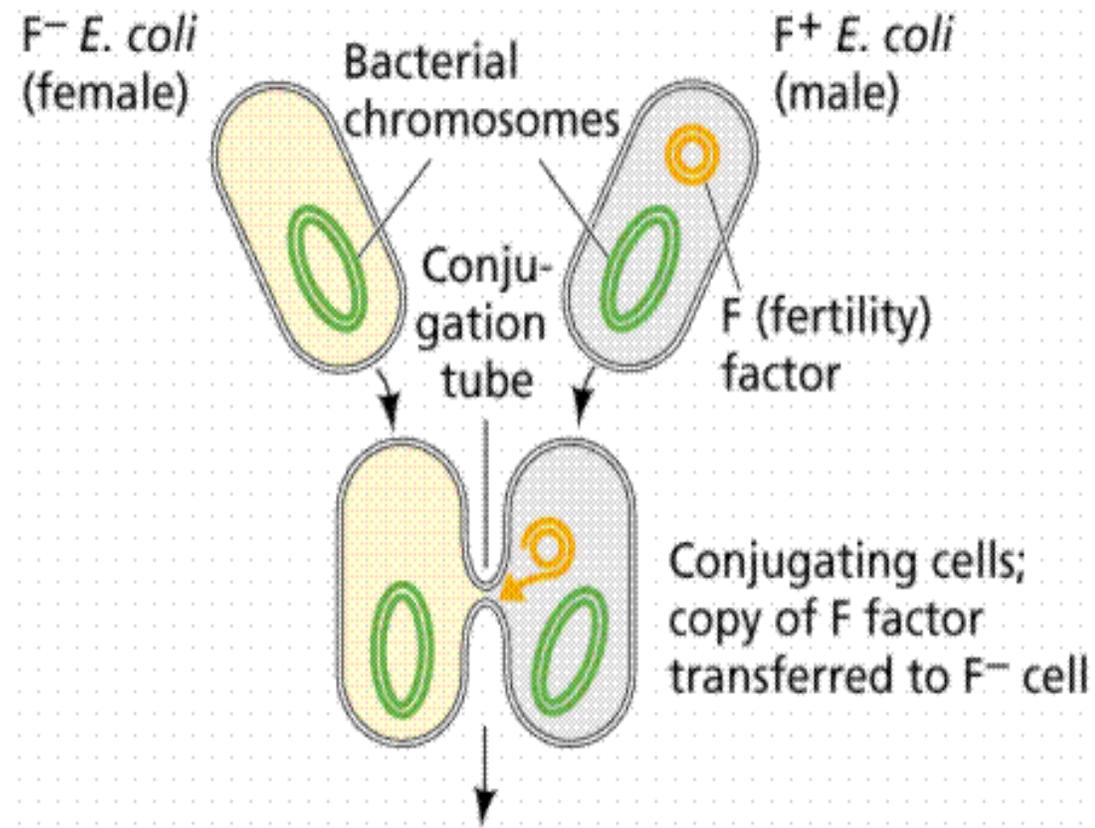
1. Independent genetic element (F+), plasmid
2. Integrated to the host DNA (Hfr), the episome
3. Independent but as part of host DNA, F' prime

- In order for the circular F factor to integrate into the recipient's cell chromosome, homologous regions must be found.
- Before integration, the F factor takes a linear state and approaches next to the homologous region on the bacterial chromosome. The fusion occurs with a single cross-over between homologous regions and Hfr cells are formed.
- After Hfr cell formation, this factor activates the synthesis mechanism by stimulating the cell for the formation of the sex pilus.

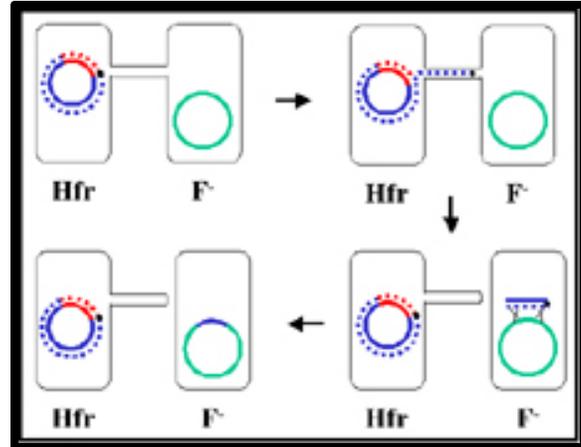
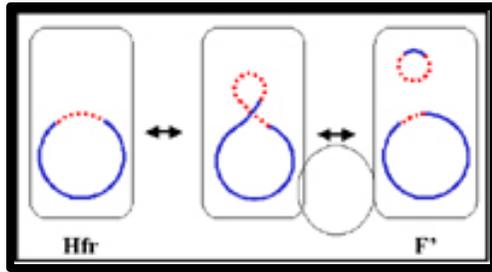
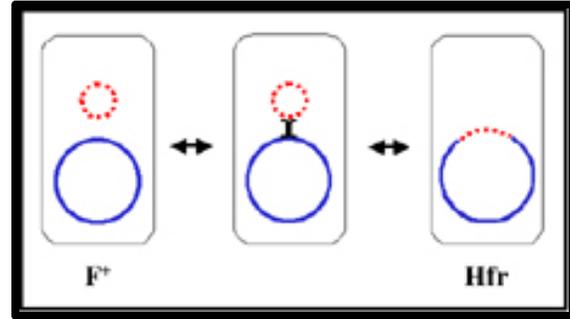
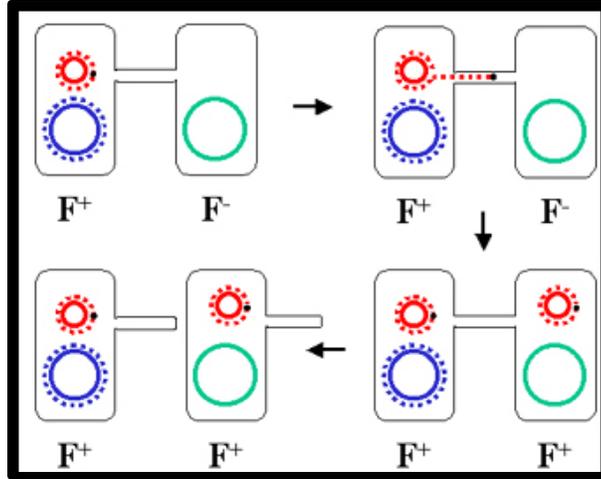
- *E. coli* K 12 strain can conjugate with other bacterial genus in Enterobacteria (*Shigella*, *Salmonella*, *Serratia*, *Proteus*, etc.)...
- Conjugation frequency and integration into the recipient cell chromosome are directly proportional to the homology between bacteria.
- In cases where there is no integration, the F factor is found in a free state (in the form of a plasmid) in the cell.

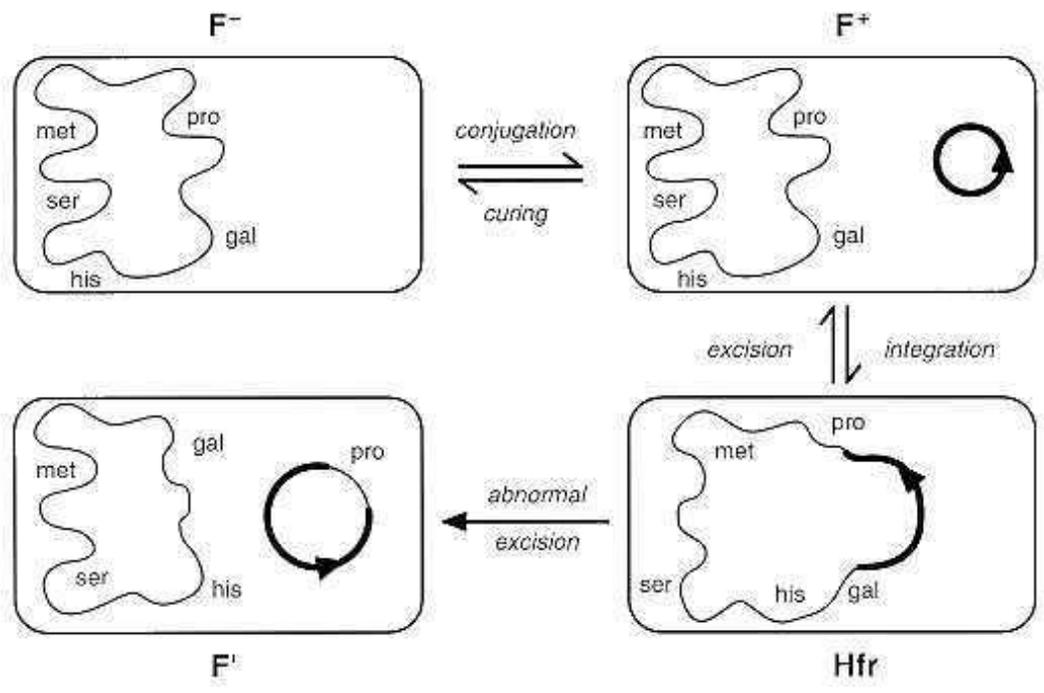
- Replicates synchronously and simultaneously with cell DNA
- The F factor containing the foreign genome fragment is called the F-prime factor (F') and the recipient cell is called the F genode.
- Sometimes, while the F factor is in the cell DNA, it is next to the galactose or lactose genes, and when it leaves, it can become an extrachromosomal genetic element by taking one of these genes with it. When this plasmid is transferred to another cell, they can transform those cells into gal<sup>+</sup> and lac<sup>+</sup>. These cells are called secondary F'-cells, and this phenomenon is called sexduction.
- In some cases, the F factor can be separated by leaving the host cell. Such cells become F<sup>-</sup>, which event (Hfr---F+---F<sup>-</sup>) is called release or healing.









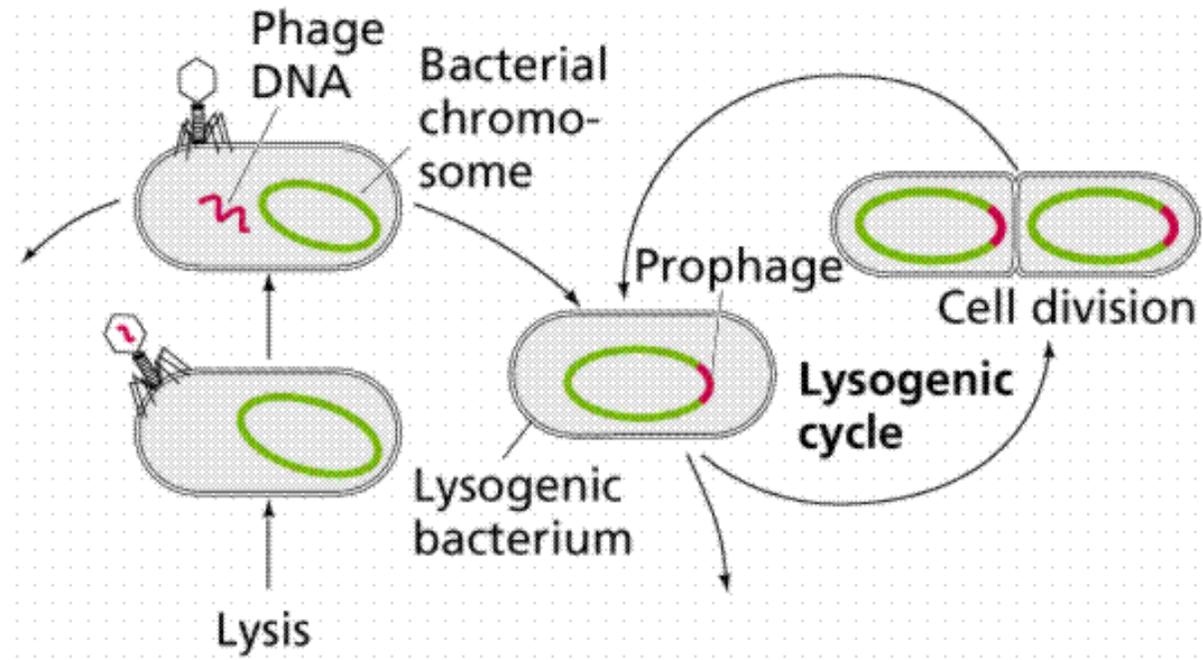


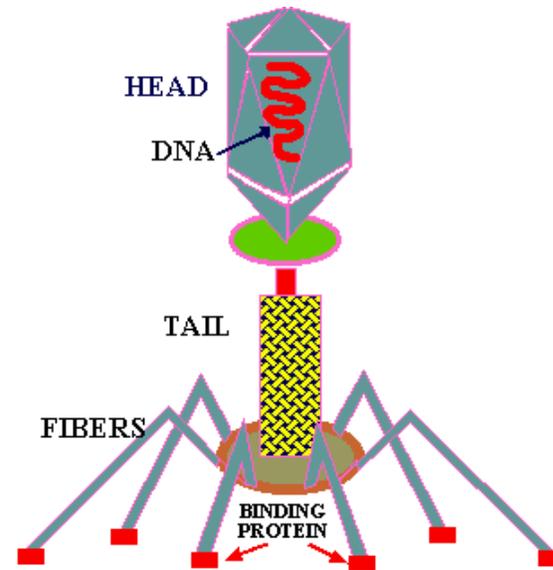
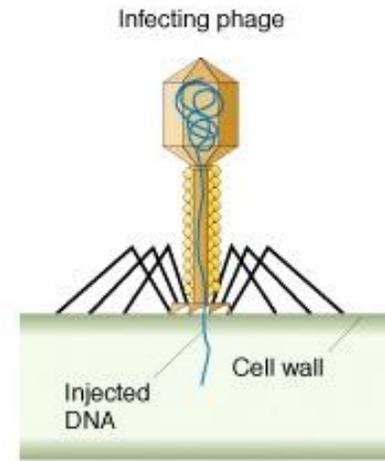
## 3. TRANSDUCTION

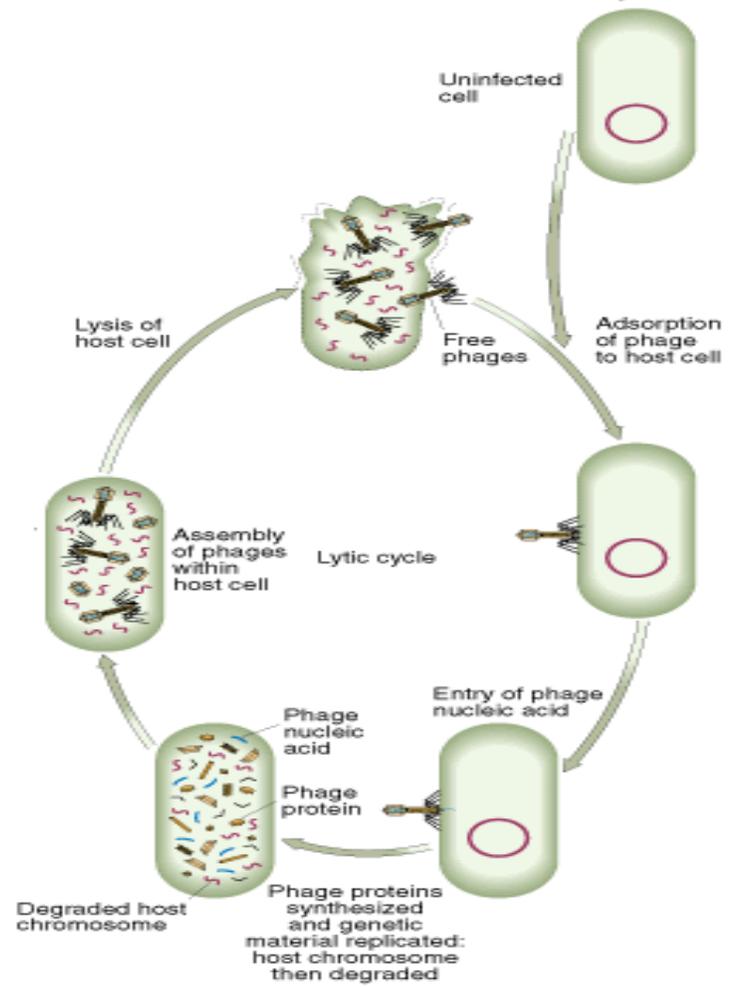
- The transfer of genetic material from a donor bacterium to a recipient bacterium via phages is called transduction.
- Gene transfer by transduction could be seen both in Gram-negative (*Salmonella*, *E. coli*, *Shigella*, *Proteus*, *Vibrio*, *P. aeruginosa*) and Gram-positive microorganisms (staphylococci and bacilli)
- Phages are viruses (bacteriophages) that break down or lyse bacteria. It is host specific and has species specificity among bacterial phages.

# Bacteriophages Types

- virulent or vegetative phages that replicate after entering the host cell and lyse the bacterium
- Bacteriophages those do not lyse the infected cell; temperate phages
- Those that combine with the host DNA; prophages
- cells containing bacteriophages as prophages; lysogenic cells





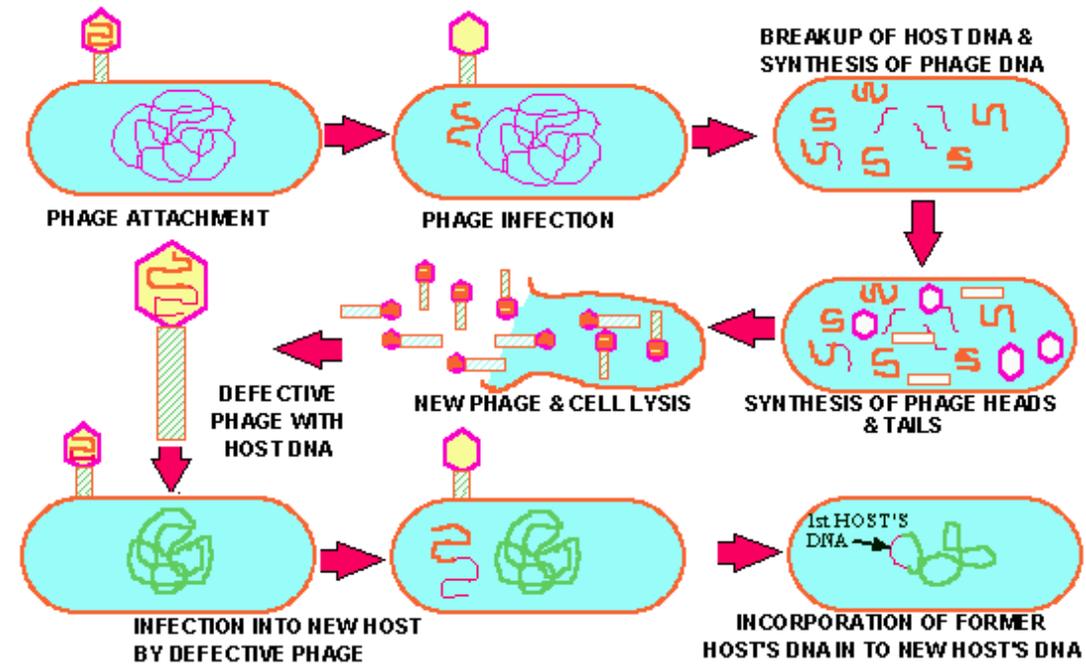


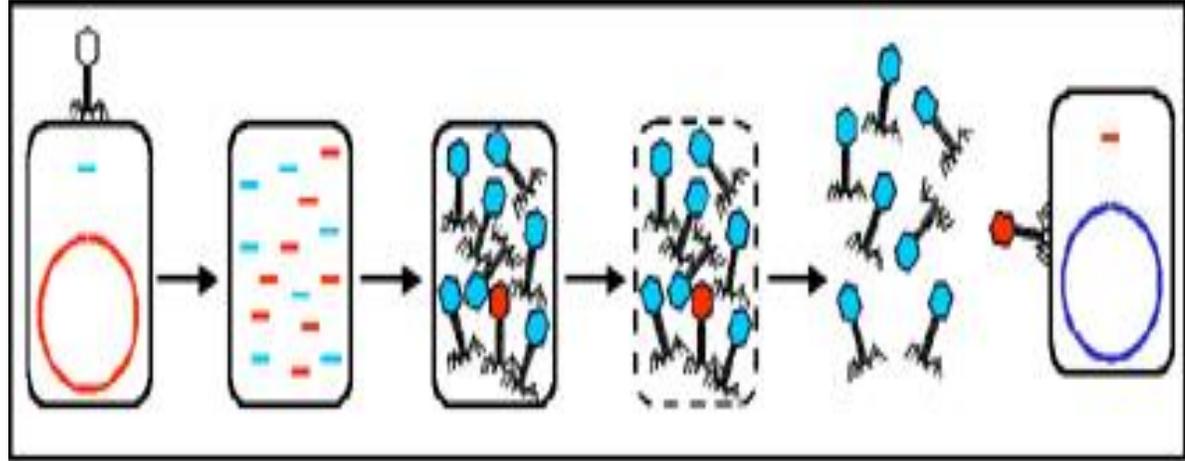
# Transduction Types

1. Generalized transduction
2. Special transduction
3. Abortive transduction

# 1. Generalized transduction

- While the phage is maturing in the bacterial cell, a segment from the fragmented host DNA may enter the phage capsid (inside the head of the phage) that is synthesized in a separate place by chance.
- Thus, when this phage infects another bacterium, it transfers its host DNA along with its own DNA to the recipient cell.
- If the phage combines with the host cell genome together with the bacterial DNA it carries, it makes the recipient cell positive in terms of the characteristics it carries.
- After several cross-overs, the recipient cell chromosome and the phage+bacteria DNA segment combine, replicating and transcribing together.
- The information in the gene it carries is transferred to the mRNA exactly and participates in the translation.





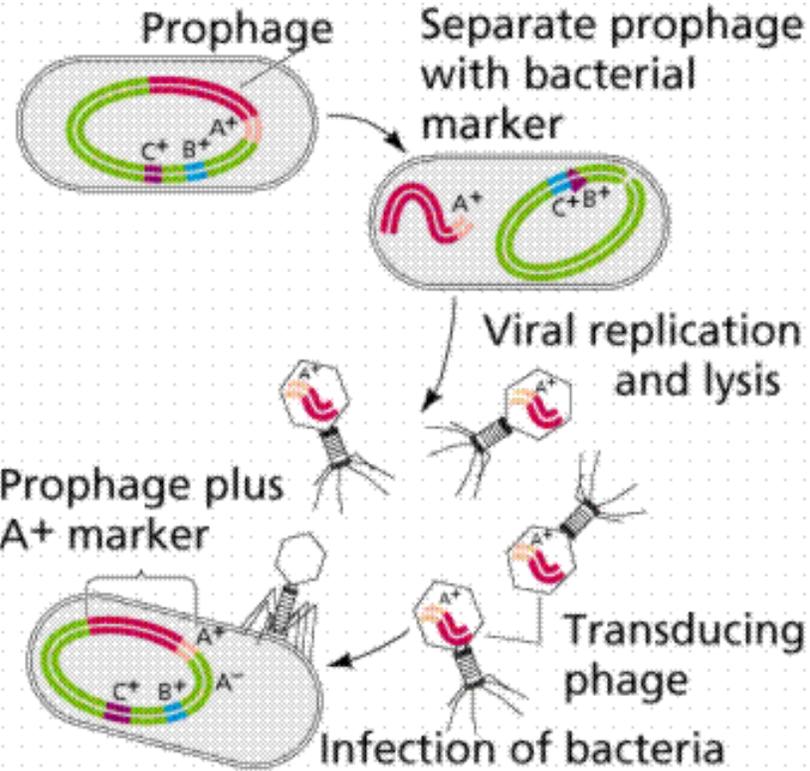
## 2. Special Transduction

- The phages that form in special transduction settle next to certain genes in the host DNA and combine with the cell DNA and turn into prophages.
- When separating from the DNA, they are separated by taking the gene belonging to the bacteria that they are with or attached to.
- When such a phage infects another cell, it transfers the gene it carries to that bacterium and makes the bacterium positive for the special characters found in the gene.

## Restricted transduction

- In some cases, the prophage may leave some of its own DNA on the host DNA as it cleaves from the host DNA and takes a segment from the host DNA.
- In this way, the missing phage genome cannot replicate and mature in another cell that it has infected. Such transduction is called restricted transduction.

# Restricted transduction



$A^-$  cell becomes  $A^+$  with incorporation of marker carried by transducing phage

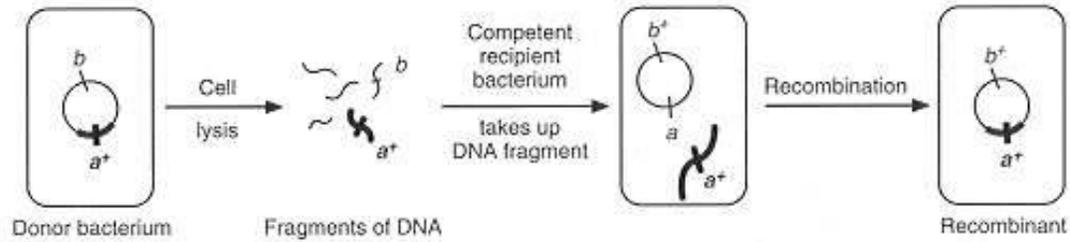
## 3. Abortive transduction

- The DNA segment taken by the phage from its host and carrying some characters (genes) is transferred to this cell when the phage infects another cell.
- However, this piece of DNA remains inside the cell and does not combine with the bacterial DNA.
- Although it exists independently in the cell, it cannot replicate simultaneously with the cell's DNA.
- It can make the cell positive in terms of the characters it carries.
- Each time the bacterium divides, this exogenote stays in a sister cell, making it positive.

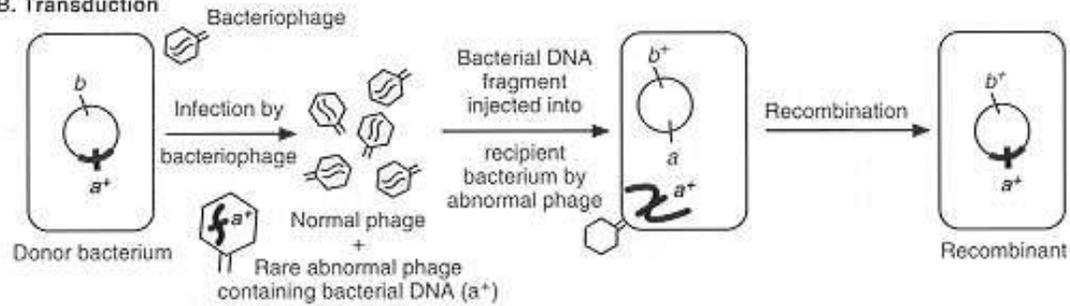
# Lizogeny and antigenic conversion

- Some bacteria become infected with phages and acquire the characters they have when they become lysogenic.
- i.e. The non-toxic strain of *C. diphtheriae* becomes virulent (toxigenic) if lysogenized by beta phage.
- Expression of some specific antigenic components in phage-infected bacteria
- i.e. Some special somatic polysaccharide antigens in *Salmonella* and *Shigella*

### A. Transformation



### B. Transduction



### C. Conjugation

