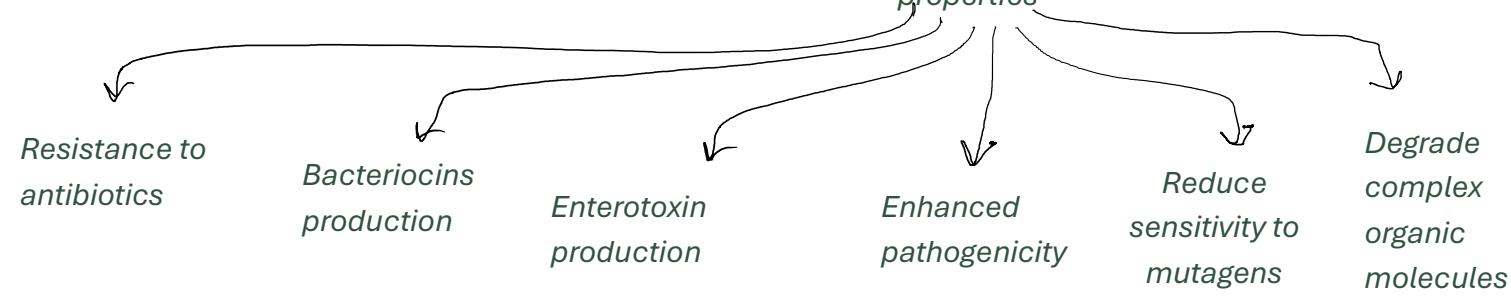
Bacterial genetics

Bacterial genetic material → bacterial chromosome, extra chromosomal genetic element

- Bacterial chromosome
  - *Double stranded DNA in circular form*
  - *1,000 microns length*
  - *Contains about 4,000 kilobases (1kb= 1000 base pairs A-T, C-G)*

- *Extra chromosomal genetic element*
  - *Not essential for survival of bacterial*
  - *Make the bacteria resistant to antibiotics(survive from antibiotics)*
  - *Make the bacteria able to produce toxins*
  - *Mainly plasmid*
    - ➔ *circular DNA molecules presented in cytoplasm*
    - ➔ *Size range1 to over 400 kilobases*
    - ➔ *Can transfer genes from one cell to another*
    - ➔ *Capable for autonomous replication*
    - ➔ *May encode genetic information for properties*



- Bacterial plasmid could be
  - *Conjugated(f+): able to be transferred into another bacterium via sex pilus(sex transfer)*
  - *Non conjugative(f-): plasmid can't initiate conjugation(cant form sex pilus)*
    - *Only transfered with help of conjugative one*

- Plasmids classifications according to it's genetic component:

Plasmid type	Gene presented	Significance of gene\plasmid
Fertility plasmid (f)	Genes for pili	Makes baterium capable to conjugation
Resistance plasmid (R)	gene s	Can build resistance against one or more antibiotics\poisons
Col-plasmid	Genes coding for colicines	Colicines protein production which can kill other bacteria
Degradative plasmid	----------	Able to digest unusual substances like: toluene, salicylic acid
Virulence plasmid	----------	Turn bacterium into pathogen

- Plasmids can be integrated with chromosomal DNA and then is called ***EPISOME***

❖ Gene transfer in bacteria

Vertical

- *Transfer of gene from mother to daughter cell*
- *Occurs mainly during reproduction of cells*
- *DNA inherited from parental organism*

Horizontal

- *Transfer of gene s between cells of the same generation in two different species*
- *DNA acquired from unrelated individuals*
- *Three main types:*
  1. *Transformation*
  2. *Transduction*
  3. *conjugation*

****genotype/ wilde type:** Represents all potential genes of bacteria cell, Its genome, All Inherited essential biological features & growth patterns.

****Phenotype**: The expressed genes. The observed characteristics of the individual bacteria species/strain. Expressed by physical & biochemical properties, Growth patterns, Fermentation products, Antibiotic resistance, Toxins production. .etc.

So Bacteria gain new genetic information through: transformation, transduction, conjugation and mutation(clarified in next page)

❖ *Mutations*

- ➢ *Any heritable change in the genetic material*
- ➢ *Could be: neutral, beneficial, harmful*
- ➢ *The mutant is the organism(or strain) whose genome carries a mutation*
- ➢ *The mutagen is the chemical, physical or biological agent that induces mutations(causing, accelerating)*
- ➢ *Could occurs spontaneously(in absence of mutagen), inducible (in the presence of a mutagen)*
- ➢ *Physical mutagens*

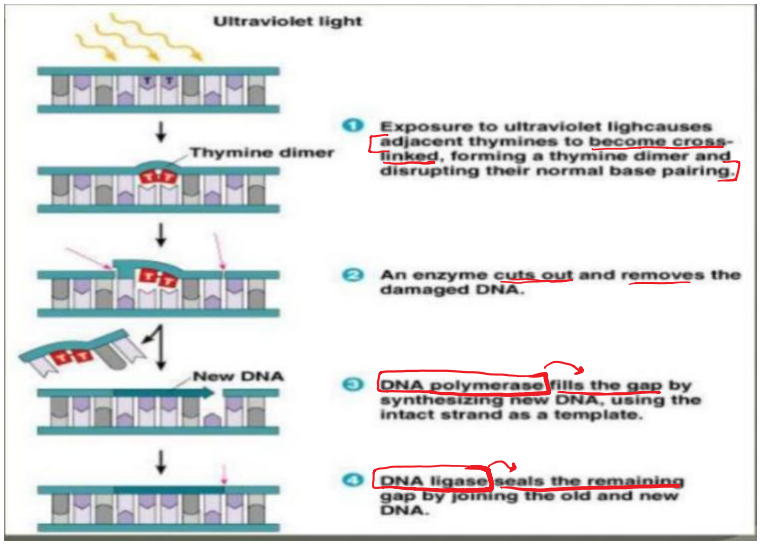
lonizing radiation

(X rays and gamma rays)

- causes the formation of ions that can react with nucleotides and the deoxyribose- phosphate backbone
- Nucleotide excision repairs mutations

Non ionizing radiation

- UV radiation causes thymine dimers
- Light-repair separates thymine dimers



- *Biological mutagents(transposons)*

Segments of DNA that can move from one region of DNA to another
This movement could be between plasmids or between plasmids and chromosomes within a single cell.

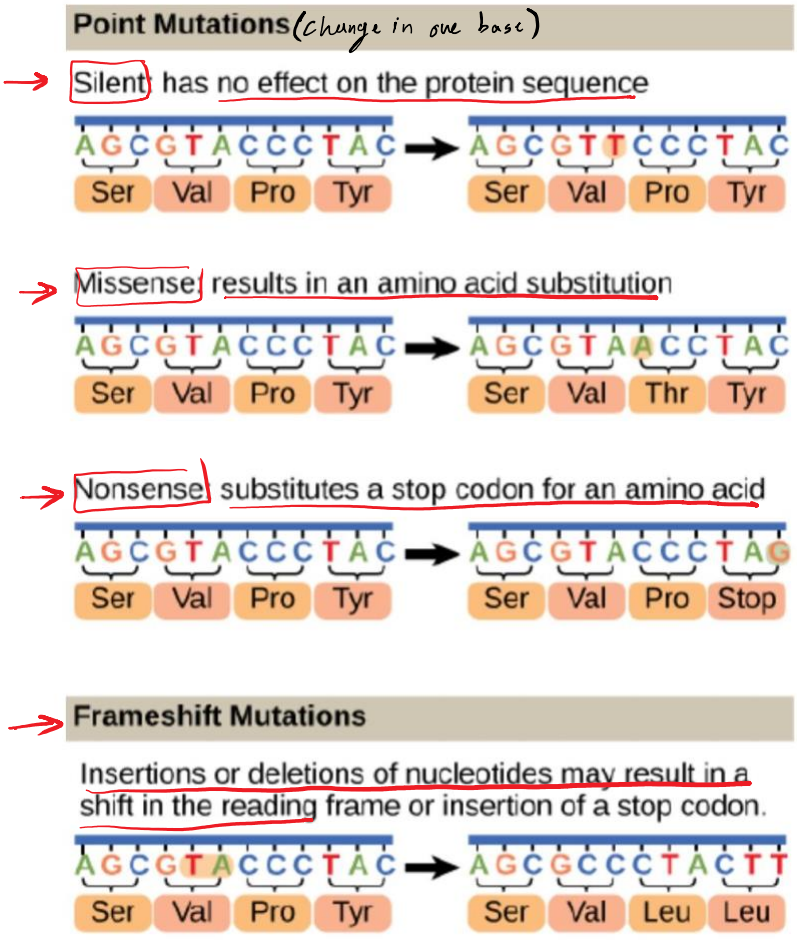
The segment contain insertioon sequences for cutting and resealing DNA through(transposase).

Mutaion could be

Gene copy and paste [class 1]

Gene cut and paste [class 2]

❖ Types of mutations

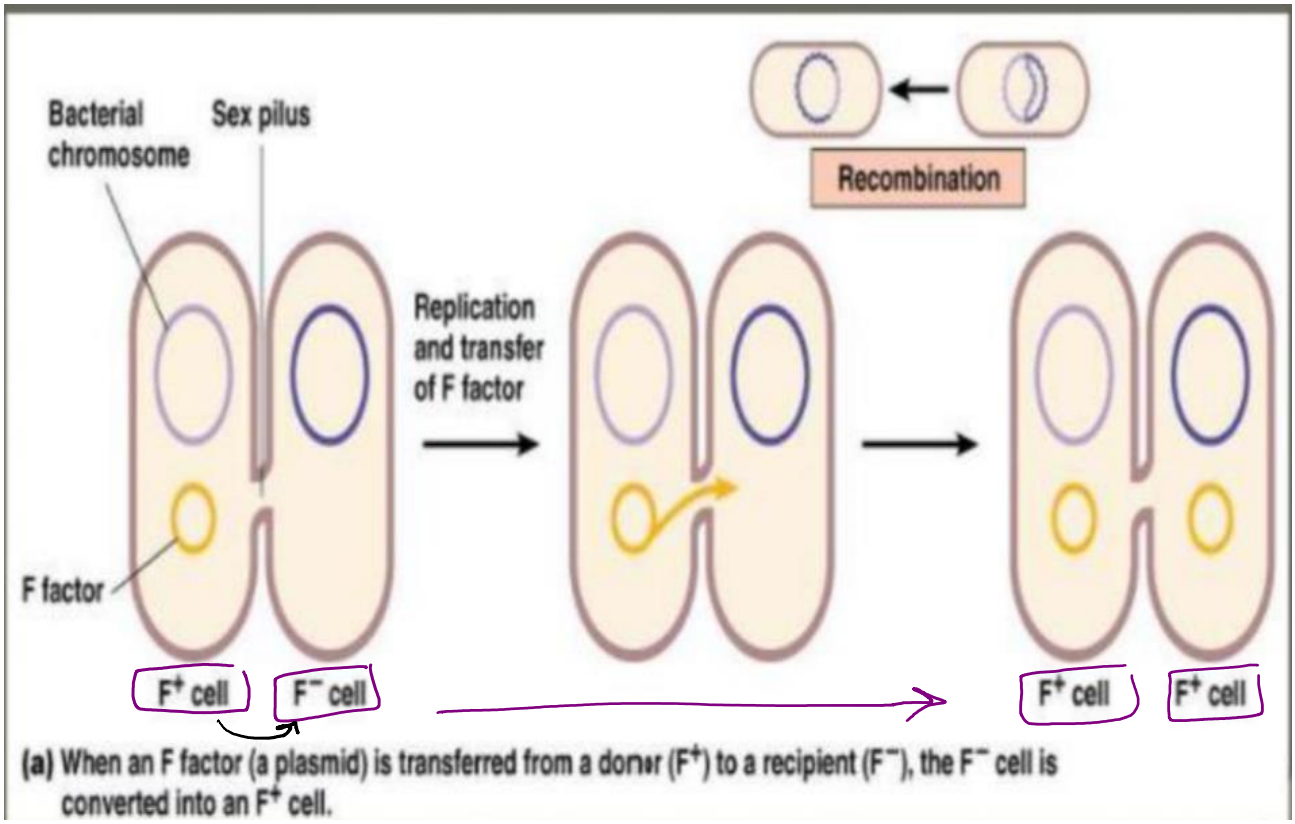


❖ *Let's talk about horizontal gene transfer methods in more details*

1. Conjugation: the closest analogue in bacteria to eukaryotic sex.

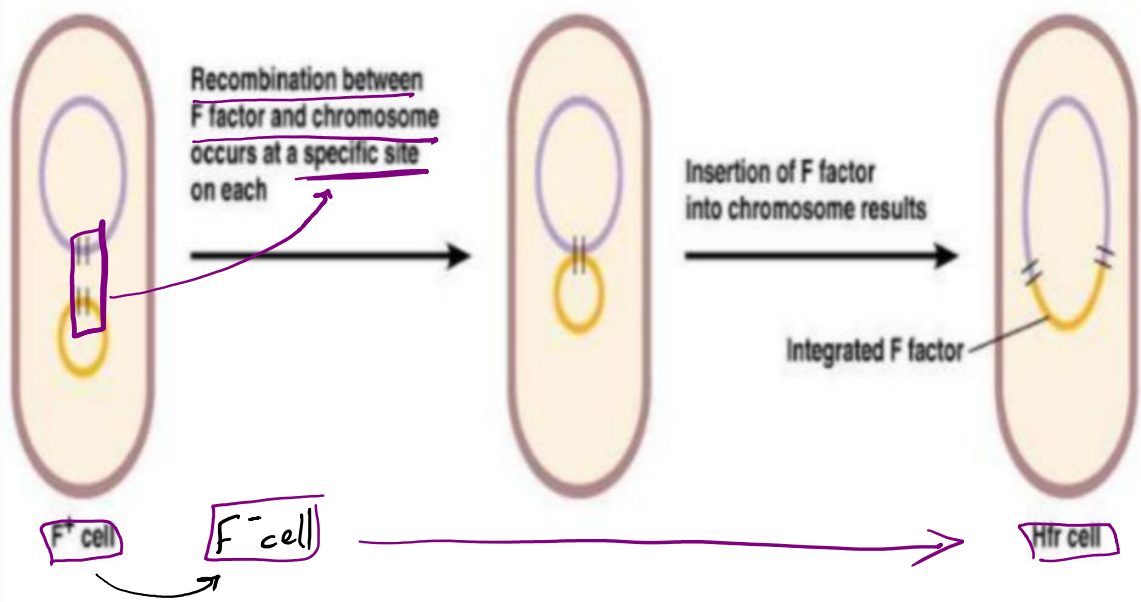
- *As we said the ability of conjugation is conferred by the F plasmidd*
- *F+ cells has ability to grow special tube called sex pilli exttened from its body[the sex pilli hold both bacteria together the donor&acceptor*
- *The transferring of F plasmid has actually 3 types:*

A) The first one[transferring the plasmid from F+ to F- making the F- bacterium to a F+ one].



**Note that the resulting cells both are F+*

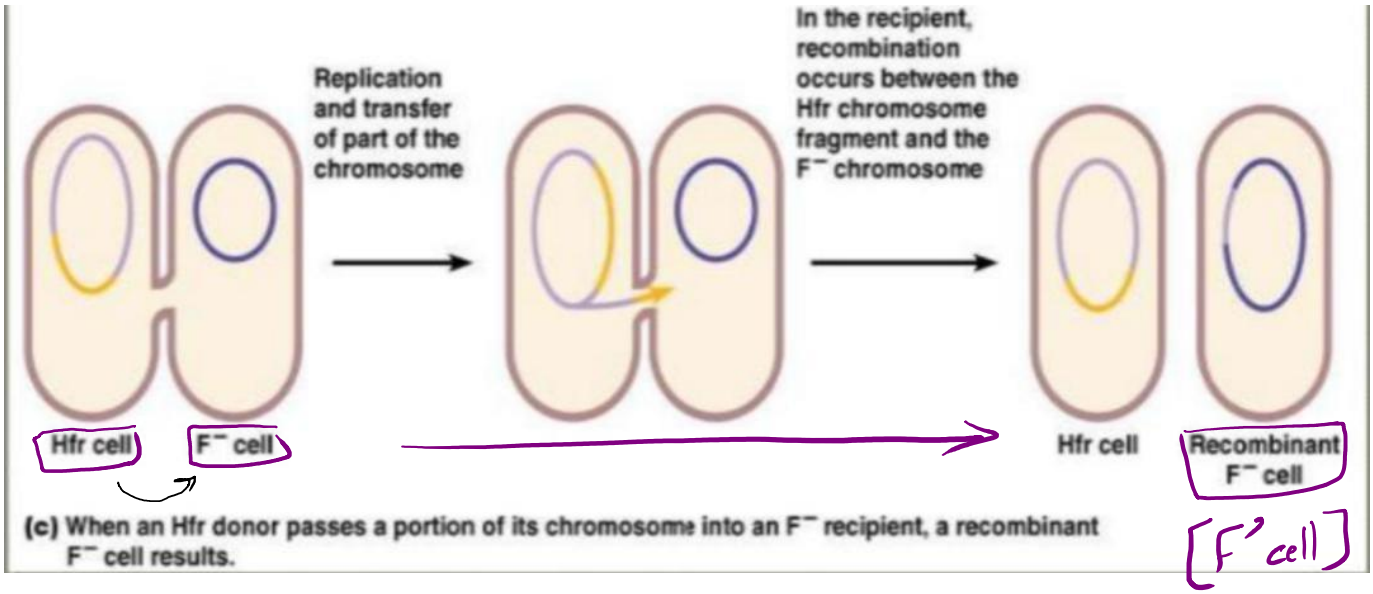
B) *The second one[transferring the plasmid of F+ bacterium into an F- bacterium but this time the transferred plasmid will be inserted into chromosome (DNA of bacterium) making the bacteria Hfr cell(high frequency of recombination cell)].*



(b) When an F factor becomes integrated into the chromosome of an F^+ cell, it makes the cell a high frequency of recombination (Hfr) cell.

C) *The third one[transferring part of the chromosome of a Hfr cell to F- bacterium cell resulting in a recombinant F- cell (f' cell)]*

-The part of chromosome transferred called F' (f prime) it contain fragment of the F factor with small portion of chromosomal DNA, so we call the recombinant F- cell a F' cell.

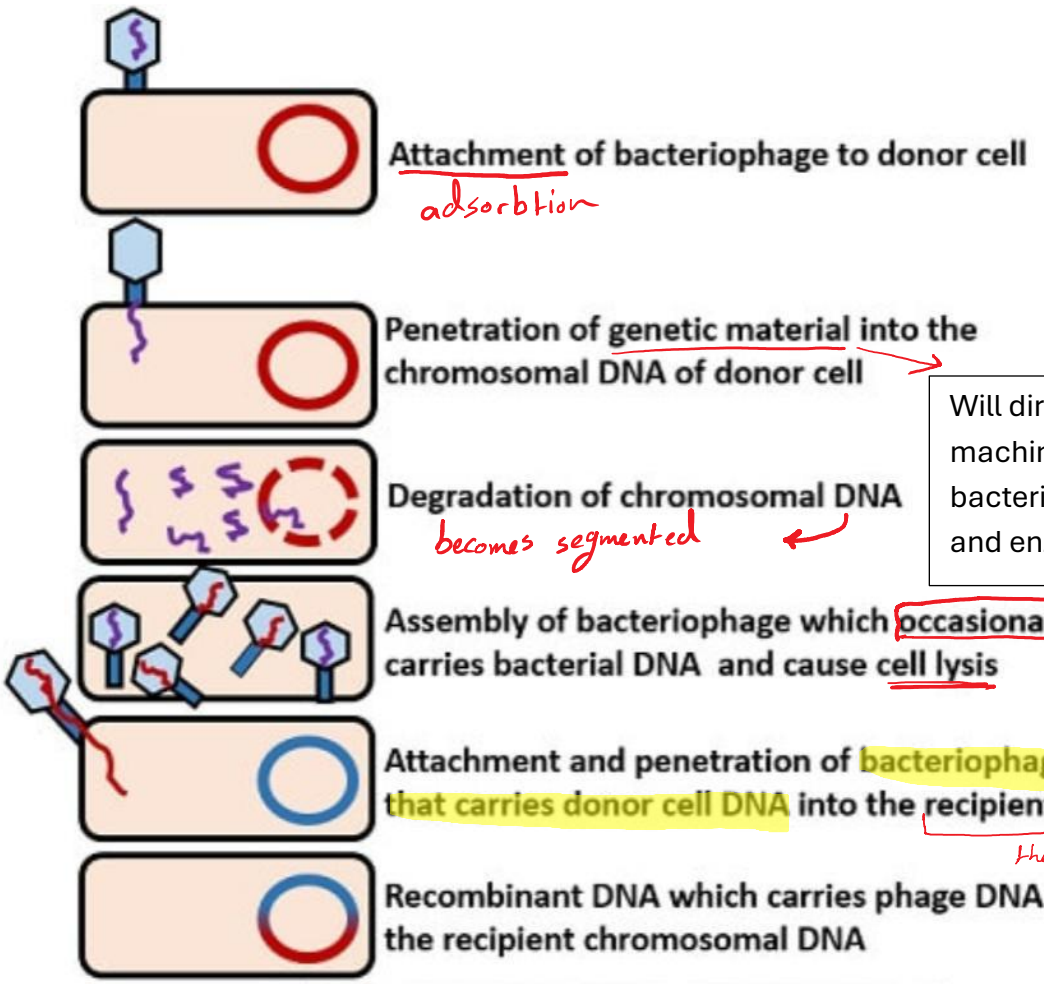


(c) When an Hfr donor passes a portion of its chromosome into an F^- recipient, a recombinant F^- cell results.

Please keep in mind that when we say transferring of plasmid or portion of the DNA we mean that it gets replicated and the copy is transferred.

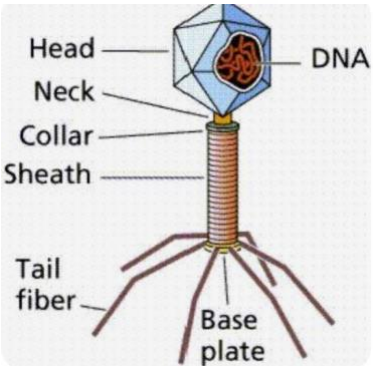
2. *Transduction: the process of moving bacterial DNA from one cell to another using bacteriophage.* *(Bacterial viruses)*

- *Tow forms presented:*
  - *A) Generalized[where any piece of bacterial genome can be transferred to another bacterium via baceriophage.]*
    -typically carries only bacteria DNA and no viral DNA.



Will direct bacterium machinery to manufacture bacteriophage components and enzymes

Generalized transduction

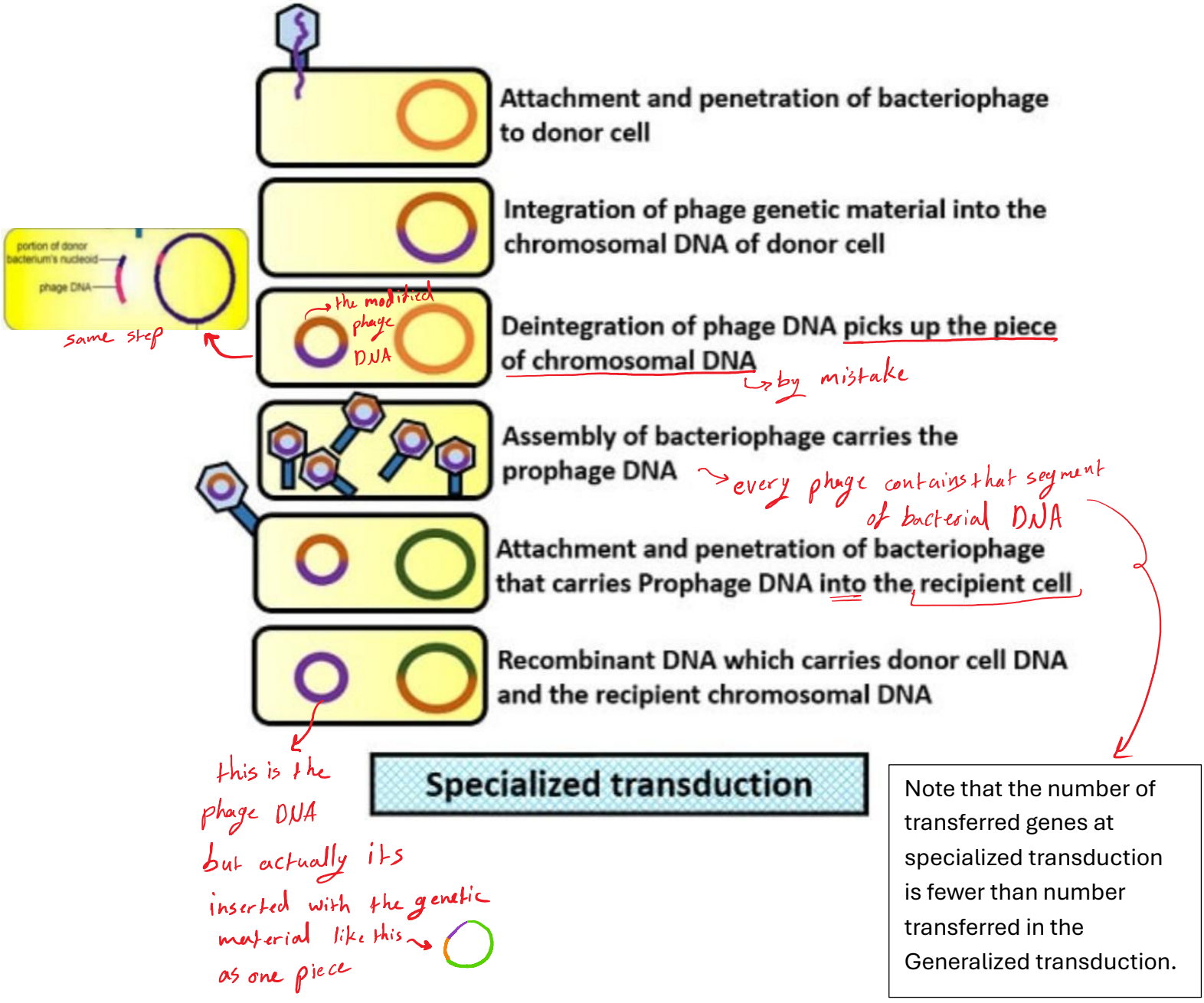


There is two types of bacteriophages: (see page 9)

- lytic - always lyse (kill) host bacterial cell
- temperate - can stably infect and coexist within bacterial cell (lysogeny) until a lytic phase is induced

B) *Specialized[bacteriophage transfer only few restricted gene(DNA fragments) and here the bacteriophage is a special type "temperate bacteriophage" which can stable infect and coexist within bacterial cell until a lytic phase is induced]*

See next page for more clarification



Note that the number of transferred genes at specialized transduction is fewer than number transferred in the Generalized transduction.

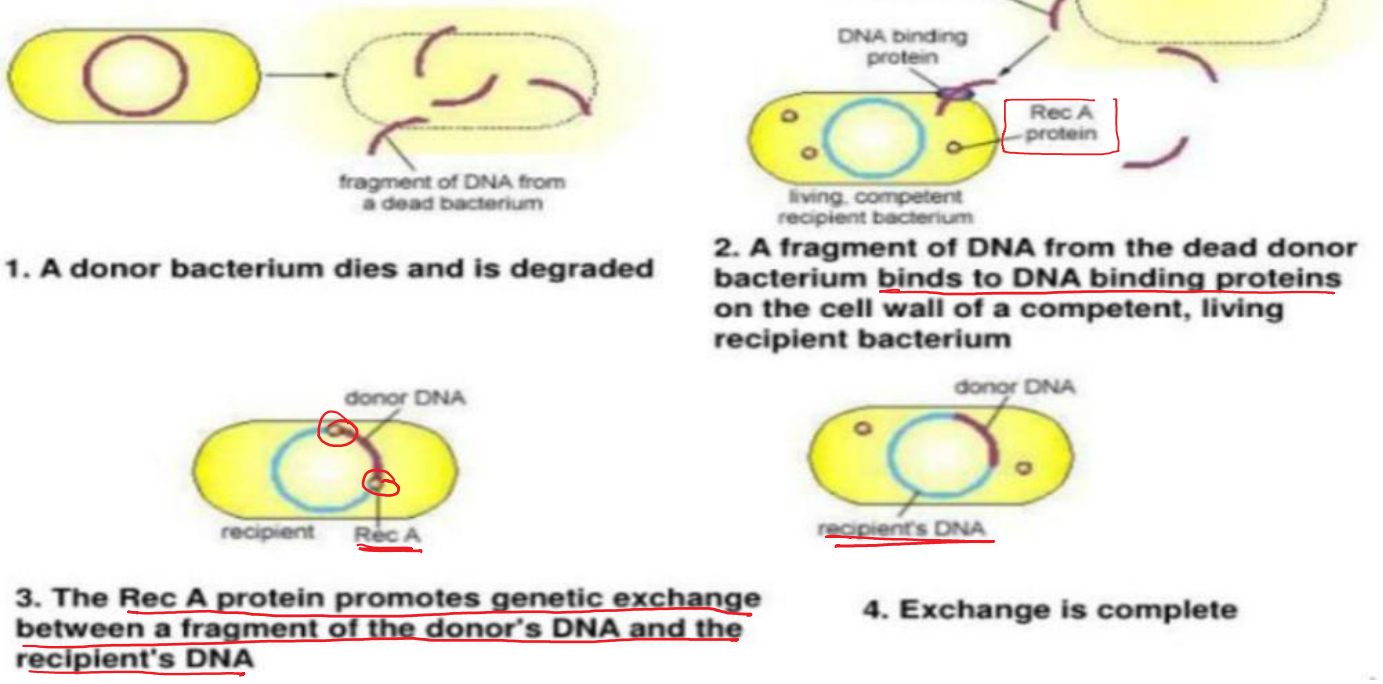
Lysogeny is a type of viral life cycle seen in certain viruses, particularly bacteriophages (viruses that infect bacteria). During lysogeny, instead of immediately replicating and destroying the host cell, the virus integrates its genetic material into the host's genome. The viral DNA, called a prophage, is inserted into the bacterial chromosome and replicates along with the host cell's DNA without causing harm.

In this state, the virus remains dormant or "latent," and the host cell continues to live and divide. Under certain conditions, such as stress or exposure to UV light, the prophage can be triggered to exit the host genome, switch to the lytic cycle, and begin active replication, leading to the production of new virus particles and, ultimately, lysis (destruction) of the host cell.

*The phage genome during lysogeny is called the prophage, and the bacterial cell is called a lysogen.

2. *Transformation the simplest way to transfer genetic material*

- *no actual cell-cell contact involved.*
- *Mostly a laboratory technique*
- *4 steps is included:*



- ✓ The DNA of donor bacterium is released to the medium as naked DNA
- ✓ The DNA is imported to another bacterium via binding to DNA binding proteins on the cell wall
- ✓ The cells able to take up DNA are said to be competent

Well done, we actually finished the lecture here but there is a small table in slides I will drag it here please read it and study it.

Prokaryotes	Eukaryotes
Prokaryotes are haploid	**eukaryotes are often diploid**
contain a **single circular chromosome**.	eukaryotes have **linear chromosomes, usually more than 1**
Prokaryotes often contain **"plasmids"**.	Doesnot contain plasmids
In prokaryotes, **translation is coupled to transcription: translation of the new RNA molecule starts before transcription is finished**	**In eukaryotes, transcription of genes in RNA occurs in the nucleus, and translation of that RNA into protein occurs in the cytoplasm**. The two processes are separated from each other.

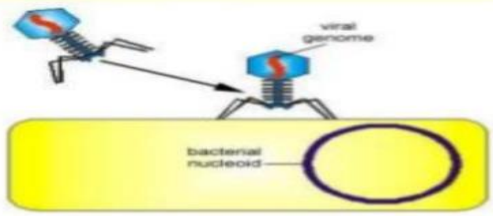
ما تنسوا اخواننا في غزّة ولبنان والسودان وكل بلادنا المستضعفة من دعائكم
أخلصوا النية لله وشدّوا هِمَمَكم، بالتوفيق!

DOPAMINE
SCIENTIFIC TEAM

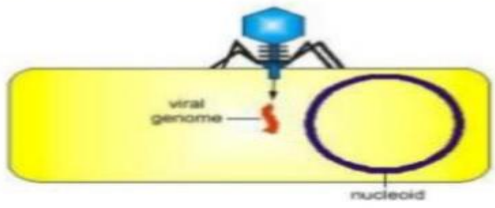
Done by: Raneem Abu Al-Haija

مُلحق

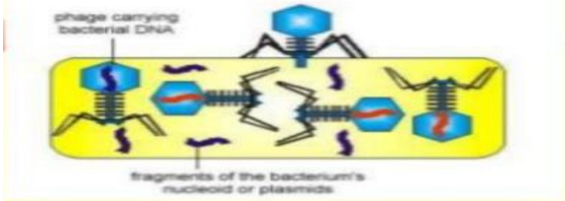
Steps of Generalized transduction as in doctor's slides you can read it quickly



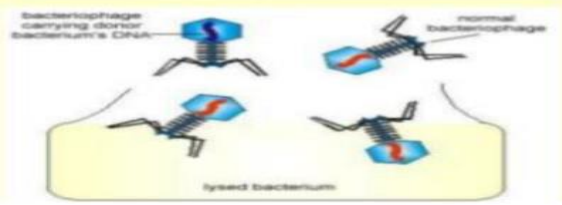
1. A lytic bacteriophage adsorbs to a susceptible bacterium.



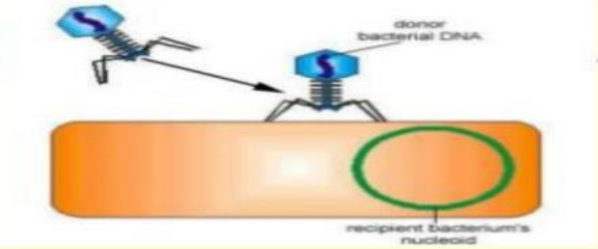
2. The bacteriophage genome enters the bacterium. The genome directs the bacterium's metabolic machinery to manufacture bacteriophage components and enzymes



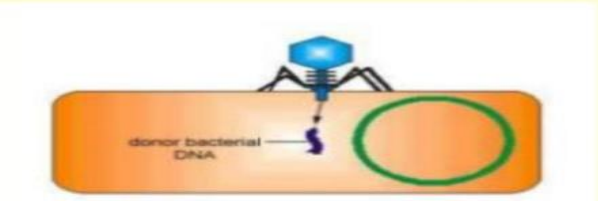
3. Occasionally, a bacteriophage head or capsid assembles around a fragment of donor bacterium's nucleoid instead of a phage genome by mistake.



4. The bacteriophages are released

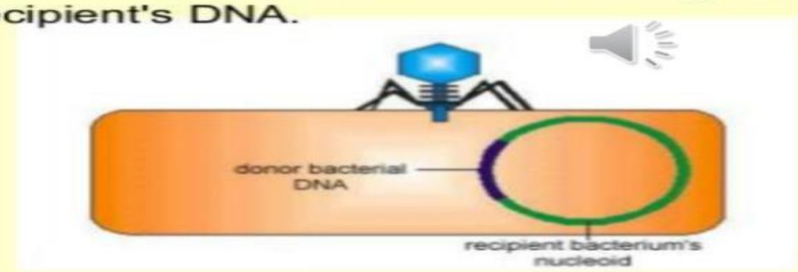


5. The bacteriophage carrying the donor bacterium's DNA adsorbs to a recipient bacterium

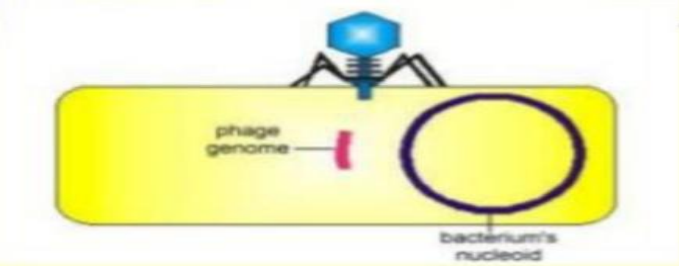


6. The bacteriophage inserts the donor bacterium's DNA it is carrying into the recipient bacterium .

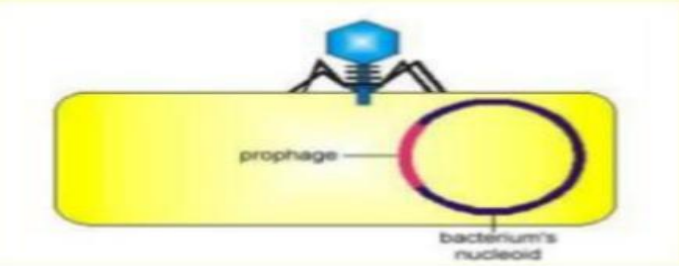
7. The donor bacterium's DNA is exchanged for some of the recipient's DNA.



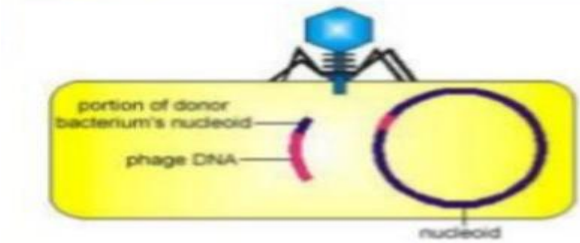
Steps of specialize transduction as in slides



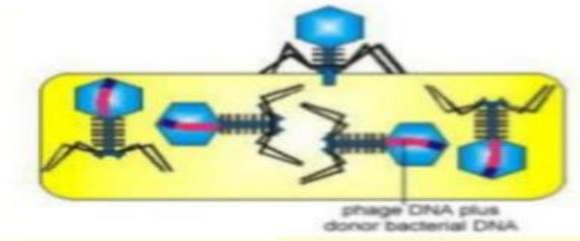
1. A temperate bacteriophage adsorbs to a susceptible bacterium and injects its genome .



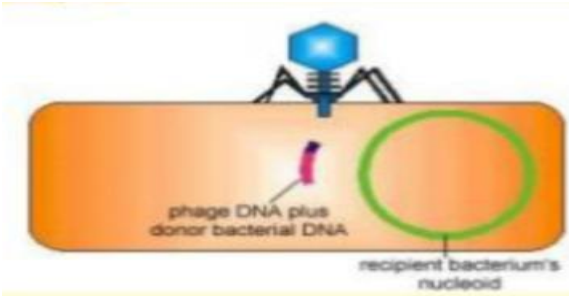
2. The bacteriophage inserts its genome into the bacterium's nucleoid to become a prophage.



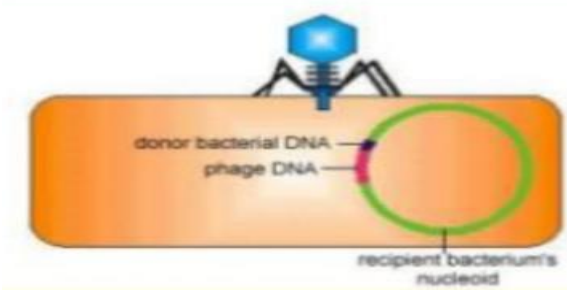
3. Occasionally during spontaneous induction, a small piece of the donor bacterium's DNA is picked up as part of the phage's genome in place of some of the phage DNA which remains in the bacterium's nucleoid.



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.