BACTERIAL GENETICS

Bacterial Genetics

- Genetics is the study of genes including the structure of genetic materials, what information is stored in the genes, how the genes are expressed and how the genetic information is transferred.

- The arrangement of genes within organisms is its genotype and the physical characteristics of an organism based on its genotype and the interaction with its environment, make up its phenotype.

Bacterial DNA

- The genetic information in bacteria is stored as a sequence of **DNA bases.**
- Prokaryotic genes are found in the bacterial chromosomes most of which are **single**, **covalently bond**, closed, **circular chromosomes** (in contrast to the linear chromosomes found in eukaryotic cells).

Bacterial DNA

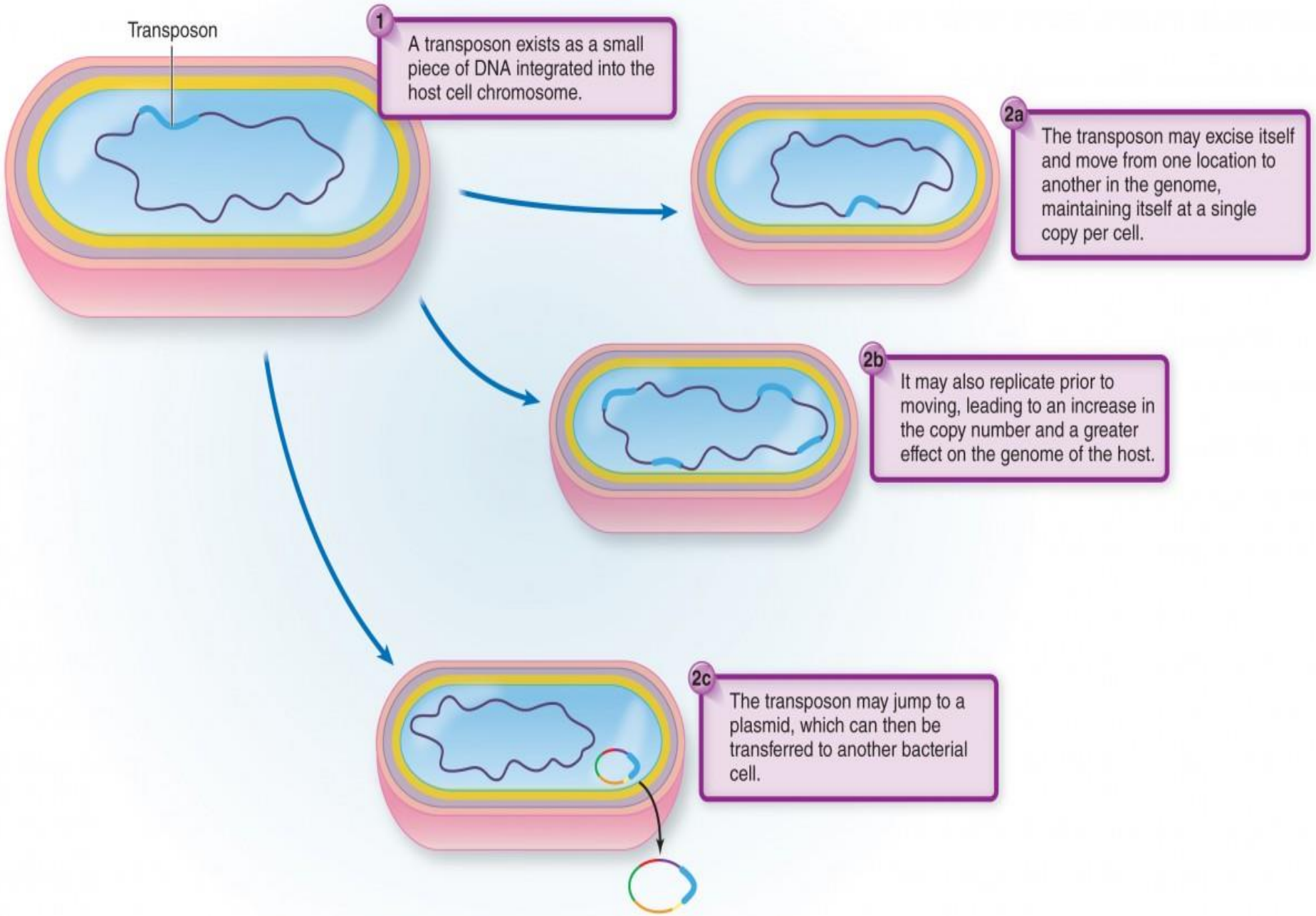
- >90% of bacteria have a single circular chromosome: some bacteria have multiple circular chromosomes.
- A few bacteria such as Brucella, *Leptospira*, and *Vibrio cholerae* have two circular strands of DNA.

Plasmids

- Plasmids are extra-chromosomal DNA found inside a bacterium. These are not essential for the survival of the bacterium but they confer certain extra advantages to the cell.
- A bacterium can have no plasmids or have many plasmids (20-30) or multiple copies of a plasmid.

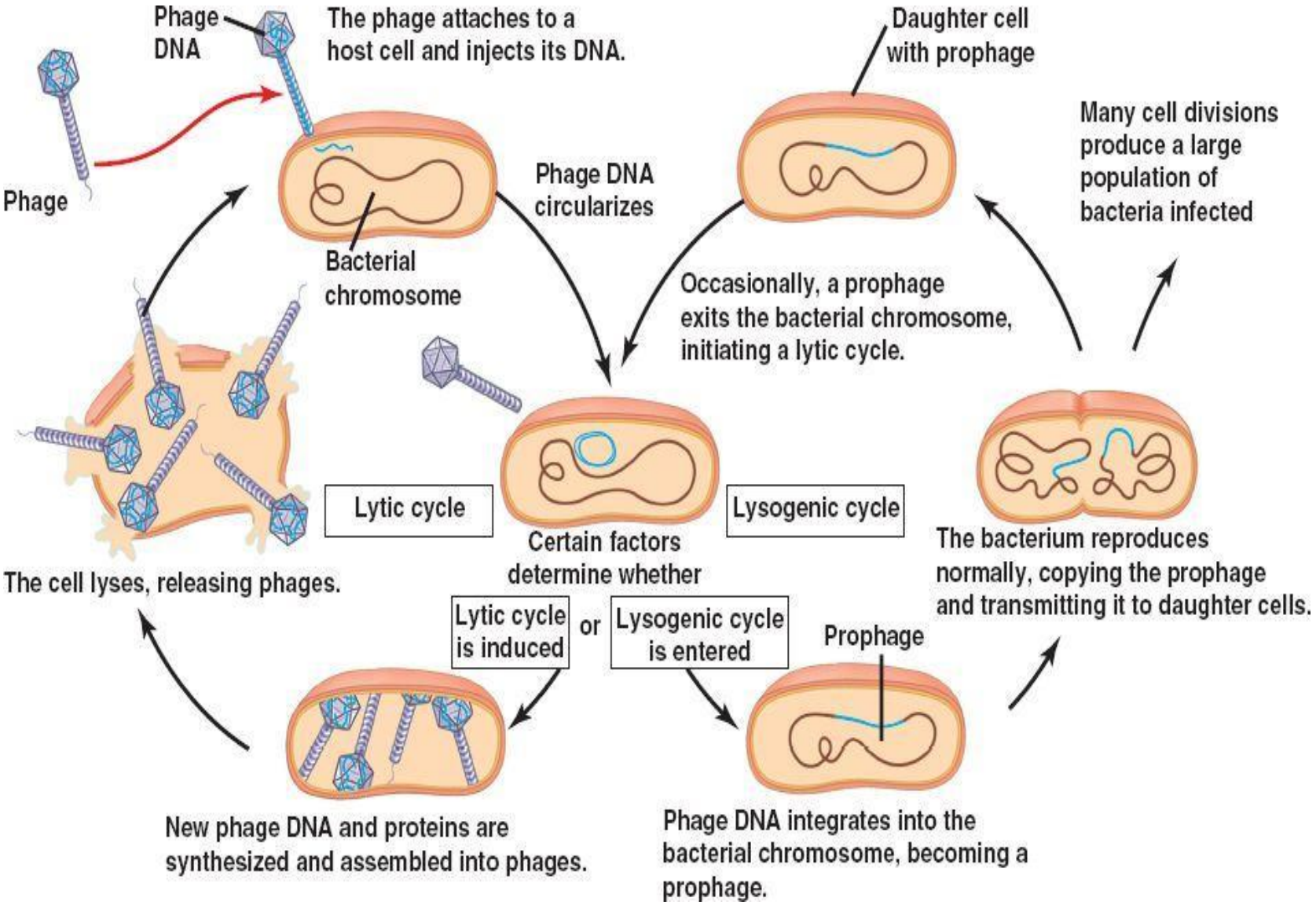
Transposons

- Transposons are genes that have the ability to move or jump around from one place to another within a chromosome.
- Sometimes they can jump from a chromosome to a plasmid. Then they would be able to be transferred to another cell as part of that plasmid.
- These genes can encode for a variety of features including **antigenic characteristics,**
- **colony morphology or colour and antibiotic resistance**



Bateriophages

- A phage is a virus that infects bacteria.
- The bacteriophage may either exist in the lytic or lysogenic phase.
- In the lytic phase, the virally infected bacterial cell is killed with the release of mature phages.
- In the lysogenic phase the DNA gets incorporated into the bacterial chromosome as prophage but the bacterial cell is not killed.


Phage
Phage DNA
The phage attaches to a host cell and injects its DNA.
Bacterial chromosome
Phage DNA circularizes
Daughter cell with prophage
Many cell divisions produce a large population of bacteria infected
Occasionally, a prophage exits the bacterial chromosome, initiating a lytic cycle.
Lytic cycle
Lysogenic cycle
Certain factors determine whether
Lytic cycle is induced
or
Lysogenic cycle is entered
Prophage
The cell lyses, releasing phages.
The bacterium reproduces normally, copying the prophage and transmitting it to daughter cells.
New phage DNA and proteins are synthesized and assembled into phages.
Phage DNA integrates into the bacterial chromosome, becoming a prophage.

Mutations

- Bacterial mutations are changes in genotype that can occur spontaneously or be induced by chemical or physical treatments.
- Mechanisms of mutations

1. Substitution of a nucleotide (also called point mutation), involves the changing of single base in the DNA sequence. This mistake is copied during replication to produce a permanent change. This is the most common mechanism of mutation.
2. Deletion or addition of a nucleotide during DNA replication, may also change the amino acid and proteins formed.

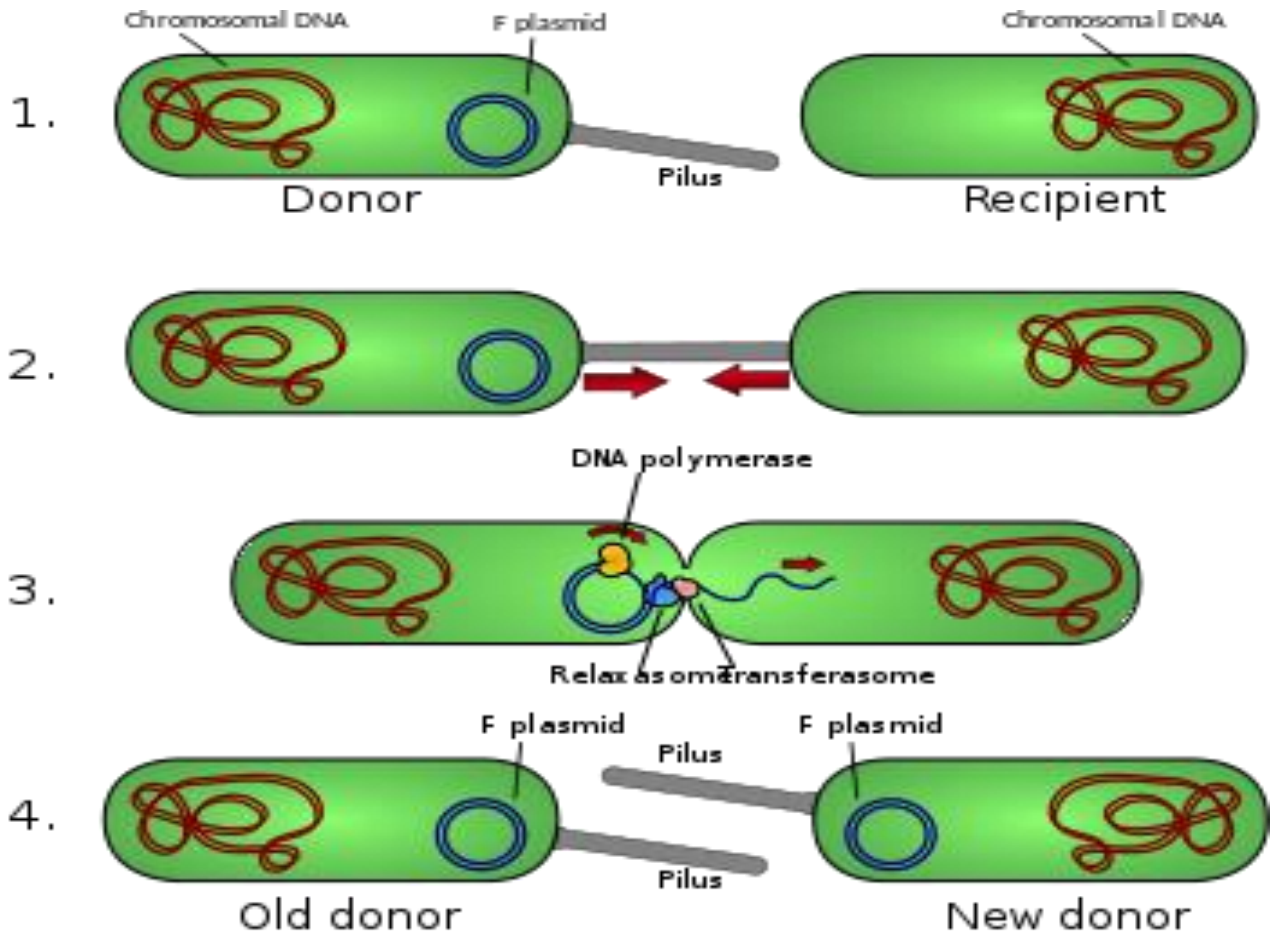
Mechanisms of gene transfer

- Genetic transfer is the mechanism by which DNA is transferred from a donor to a recipient.
- In bacteria genetic transfer can happen three ways:
    1. Conjugation
    2. Transduction
    3. Transformation

Conjugation

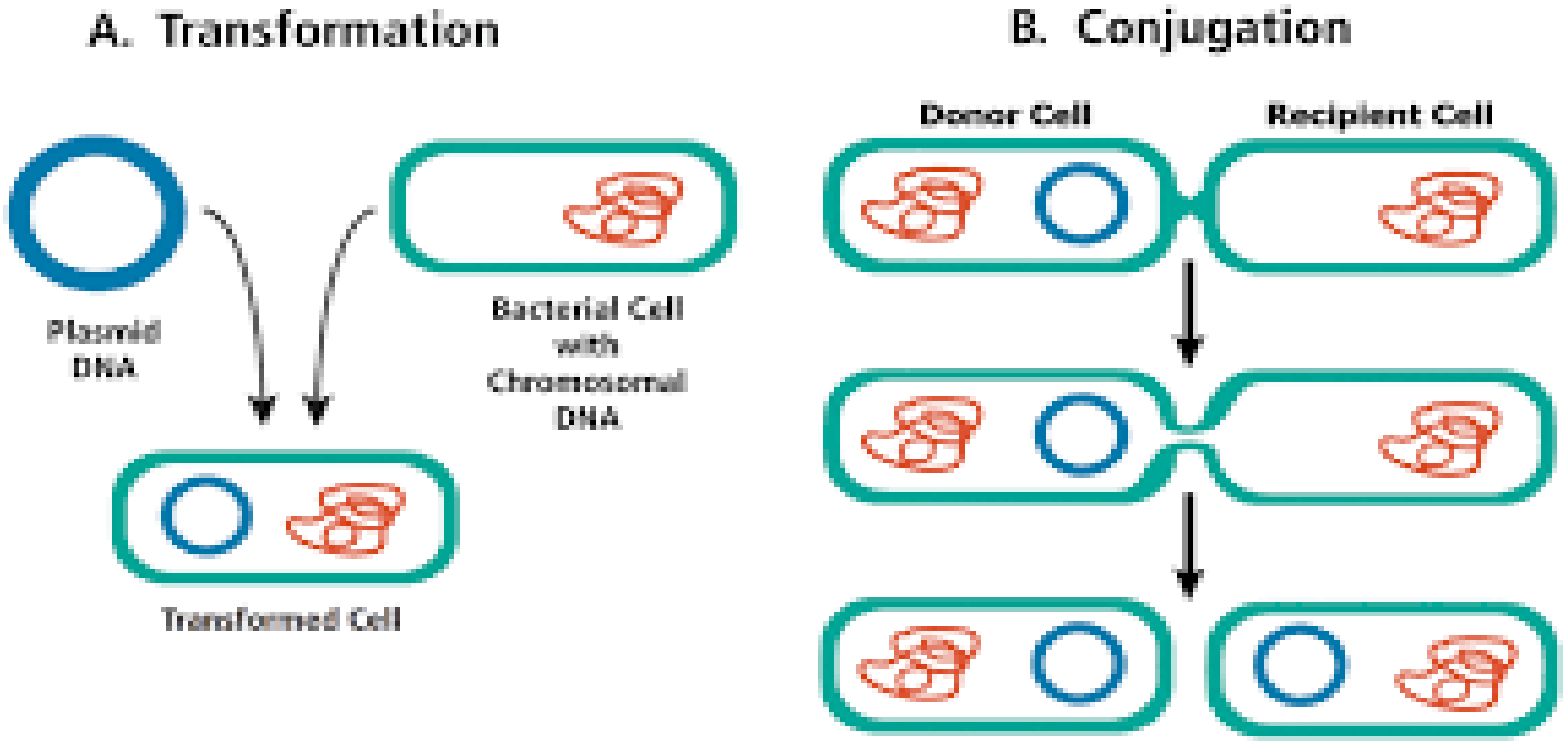
- Bacterial conjugation is the transfer of genetic material between bacterial cells by direct cell-to-cell contact or by a bridge-like connection between two cells.

A **conjugation** event occurs when the cell extends its sex pili and attaches another bacterial cell. This attached pilus is a temporary cytoplasmic bridge through which a replicating plasmid is transferred.



Transformation

- After death or cell lyses, some bacteria release their DNA into the environment.
- Other bacteria, generally of the same species, can come into contact with these fragments, take them up and incorporate them into their DNA by recombination.


A. Transformation
Plasmid DNA
Bacterial Cell with Chromosomal DNA
Transformed Cell
B. Conjugation
Donor Cell
Recipient Cell

Transduction

- Transduction is the process by which a virus transfers genetic material from one bacterium to another by phages.
- Phages are able to infect bacterial cells and use them as hosts to make more viruses.
- After multiplying, these viruses assemble and occasionally remove a portion of the host cell's bacterial DNA.
- Later, when one of these bacteriophages infects a new host cell, this piece of bacterial DNA may be incorporated into the genome of the new host

Generalized and specialized transduction

- In generalized transduction, the bacteriophages can pick up any portion of the host's genome.
- In specialized transduction, the bacteriophages pick up only specific portions of the host's DNA.
- Scientists have taken advantage of the transduction process to stably introduce genes of interest into various host cells using viruses.