General Microbiology/ 2nd year

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Bacterial Genetics

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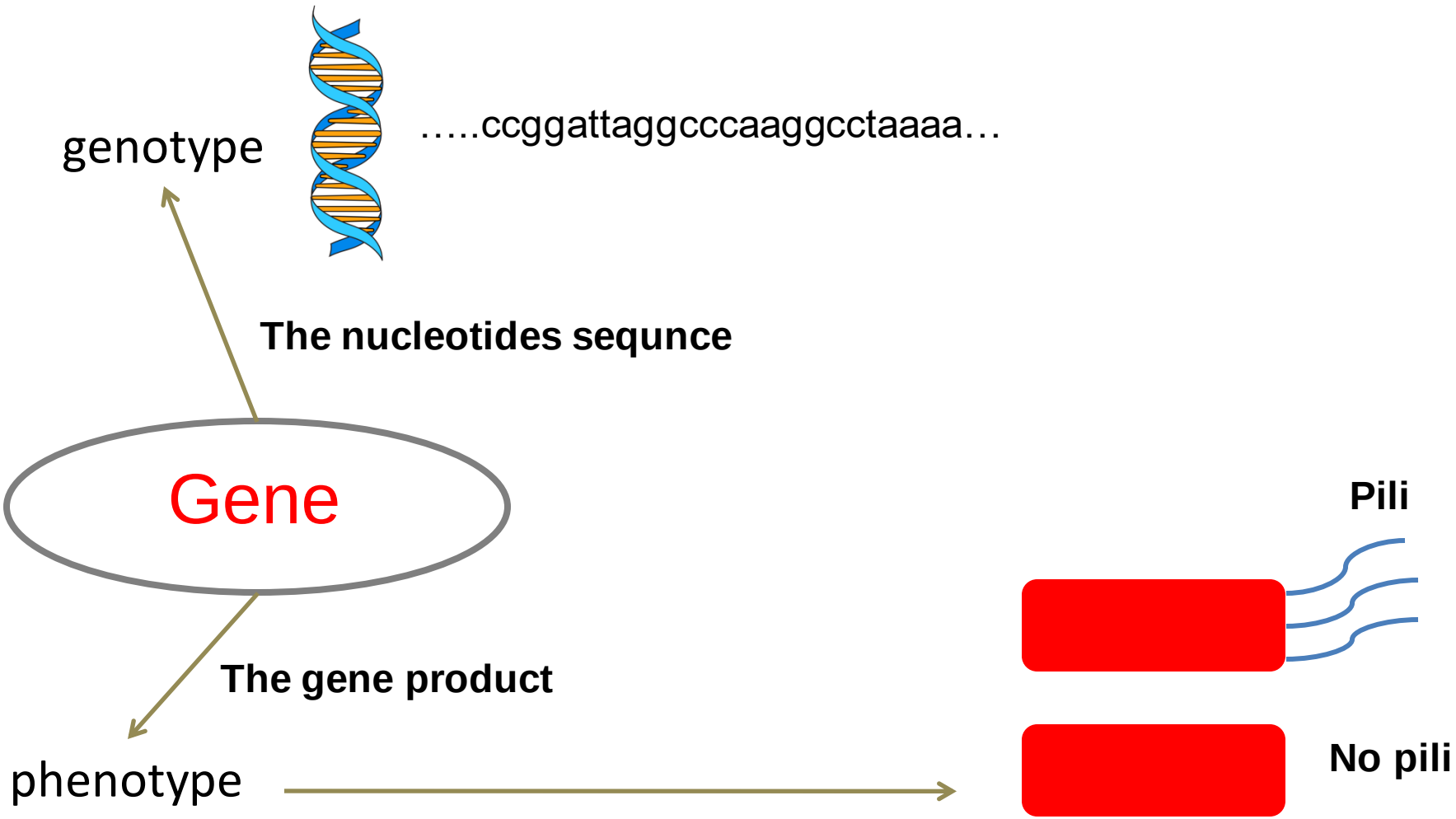
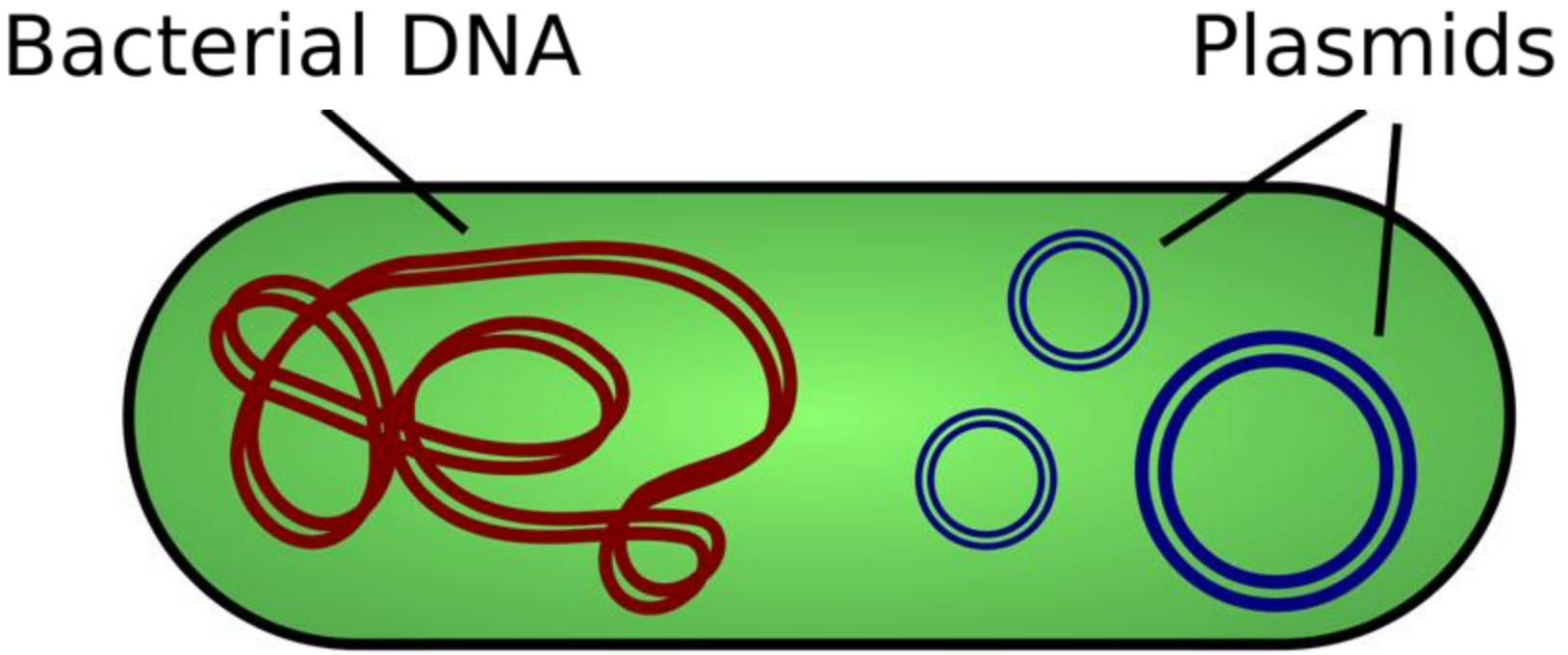
Definitions

- **An organism phenotype vs. An organism genotype**



Bcatrial DNA



plasmid

- A **plasmid** is a small DNA molecule within a cell that is physically separated from a chromosomal DNA and can replicate independently.
- They are most commonly found in bacteria as small circular, double-stranded DNA molecules
- Plasmids almost always carry at least one gene.
- Many of the genes carried by a plasmid are beneficial for the cells
- Some of these genes encode traits for
    - antibiotic resistance
    - resistance to heavy metal
    - virulence factors that enable a bacterium to colonize a host and overcome its defences
    - specific metabolic functions that allow the bacterium to utilize a particular nutrient including the ability to degrade toxic organic compounds.
    - Can also provide bacteria with the ability to fix nitrogen.

Factors affecting bacterial genes

Normal gene GCCGAATTTCACGGCCATTGCCATTAG

Mutations

Acquiring of new genetic materials

- ✓Transformation
- ✓ Transduction
- ✓ Conjugation

Abnormal gene GCCGAATTT **GCT** GGCCATTGCCATTAG **AAGGC…**

Factors affecting bacterial genes

GCCGAATTT **GCT** GGCCATTGCCATTAG

Mutations

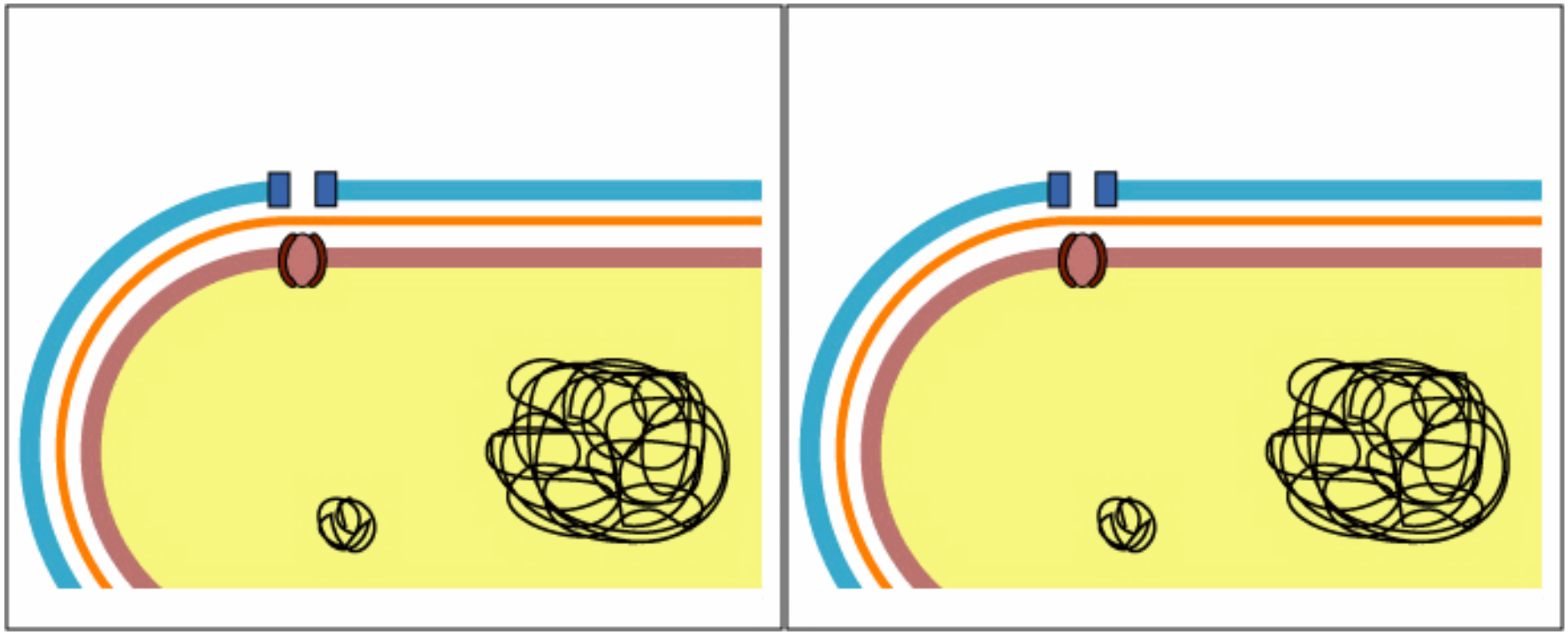
a. Natural mutations
   - Beneficial mutations
   - Harmful (lethal) mutations
   - Silent mutations

b. Induced mutations

Factors affecting bacterial genes

Example on Beneficial mutations

- Mutations enable the bacterium to survive exposure to various antibiotics. Such mutations may affect enzymatic activities , regulatory, or transport systems.



- Mutations enable bacteria to survive temporary exposure to high temperatures or starvation

Factors affecting bacterial genes

Acquiring of new genetic materials: Bacteria developed different ways to exchange genetic material

- **Transformation -** Bacteria incorporate DNA from their environment into their genome (i.e., the Griffith experiment).
- **Transduction -** Movement of DNA between bacteria by viruses.
- **Conjugation -** The direct transfer of DNA by bacteria usually via plasmids.

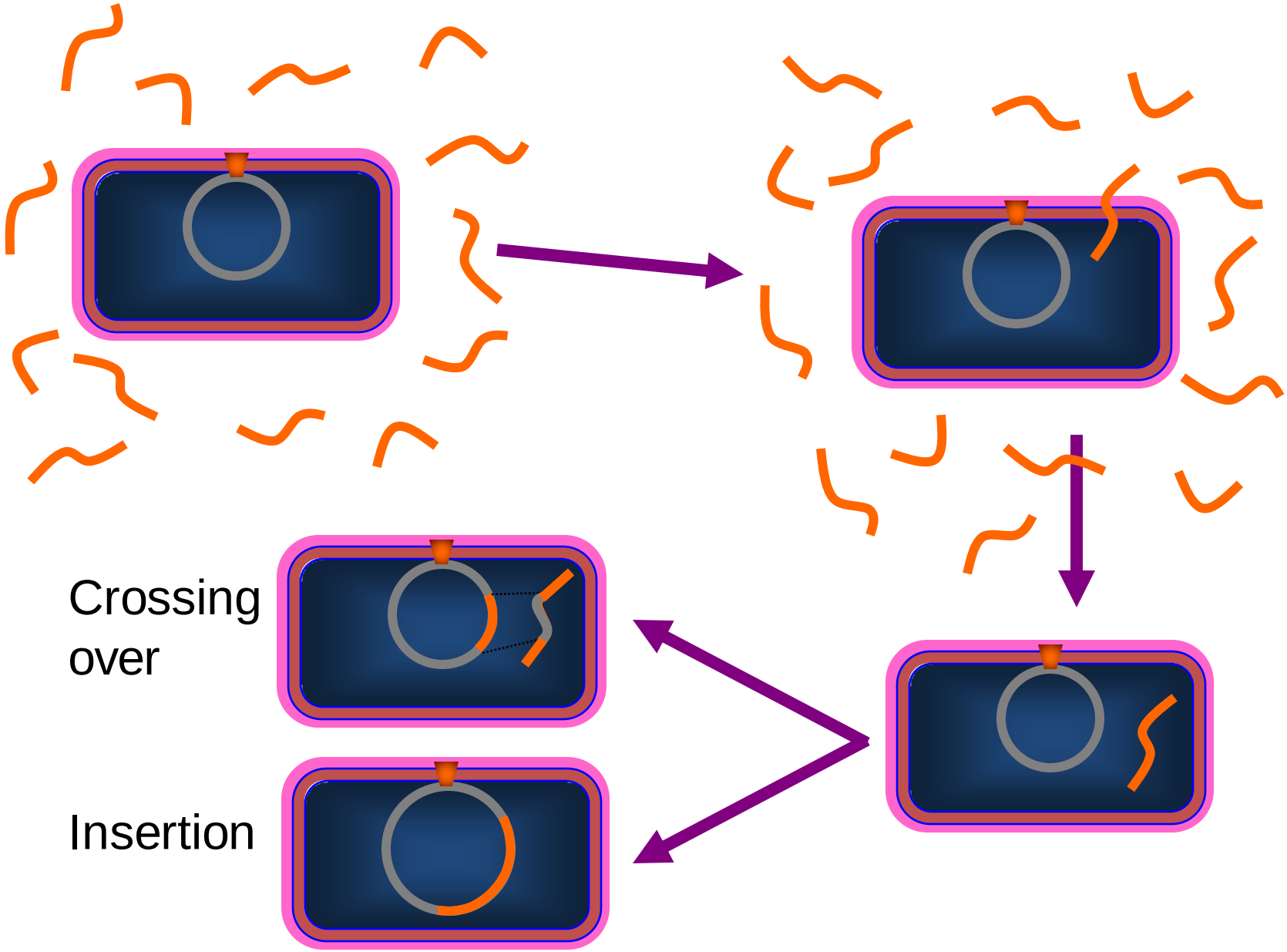
Factors affecting bacterial genes

Transformation

- The uptake by the bacterium of naked DNA
- Types:

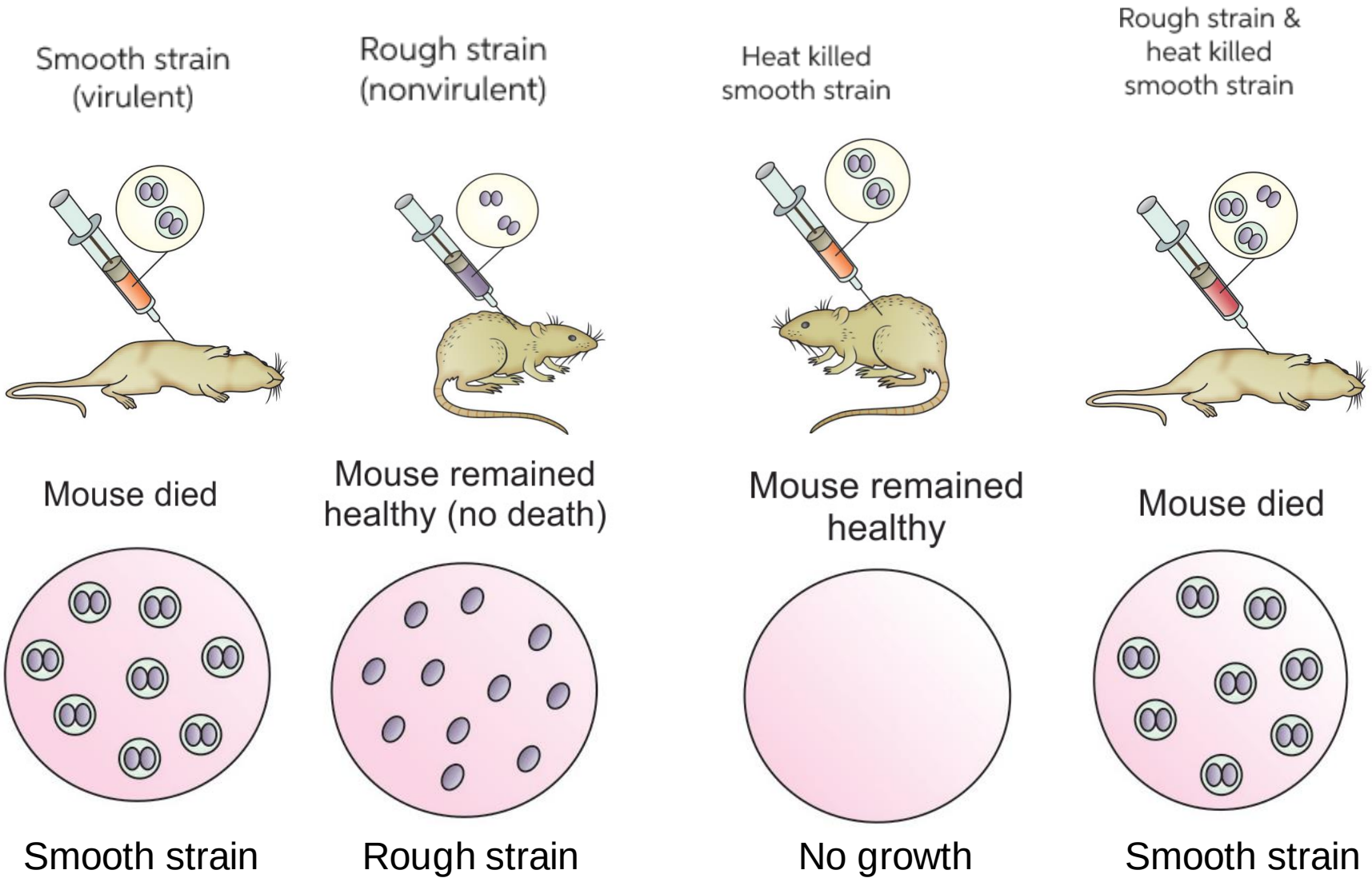
1. **Natural**: The uptake by the bacterium of naked DNA from the environment. Some bacteria have membrane proteins specialized for this function.
2. **Artificial**: uptake of DNA by a process called recombination or cloning.

Transformation



Natural Transformation

Griffith's Experiments with *Pneumococcus*



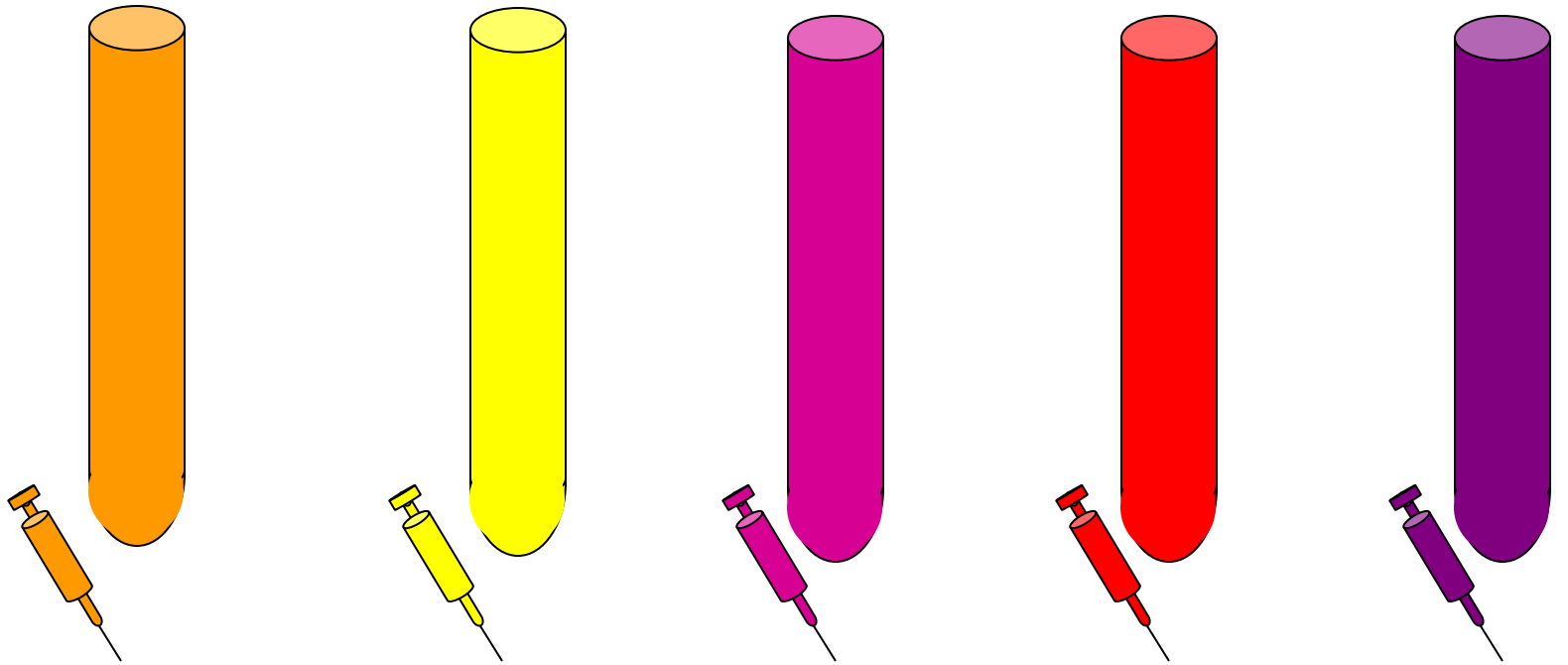
S-Type Carbohydrates Destroyed

S-Type Lipids Destroyed

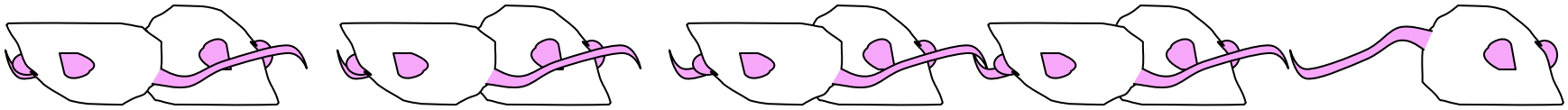
S-Type Proteins Destroyed

S-Type RNA Destroyed

S-Type DNA Destroyed



+ Rough strain

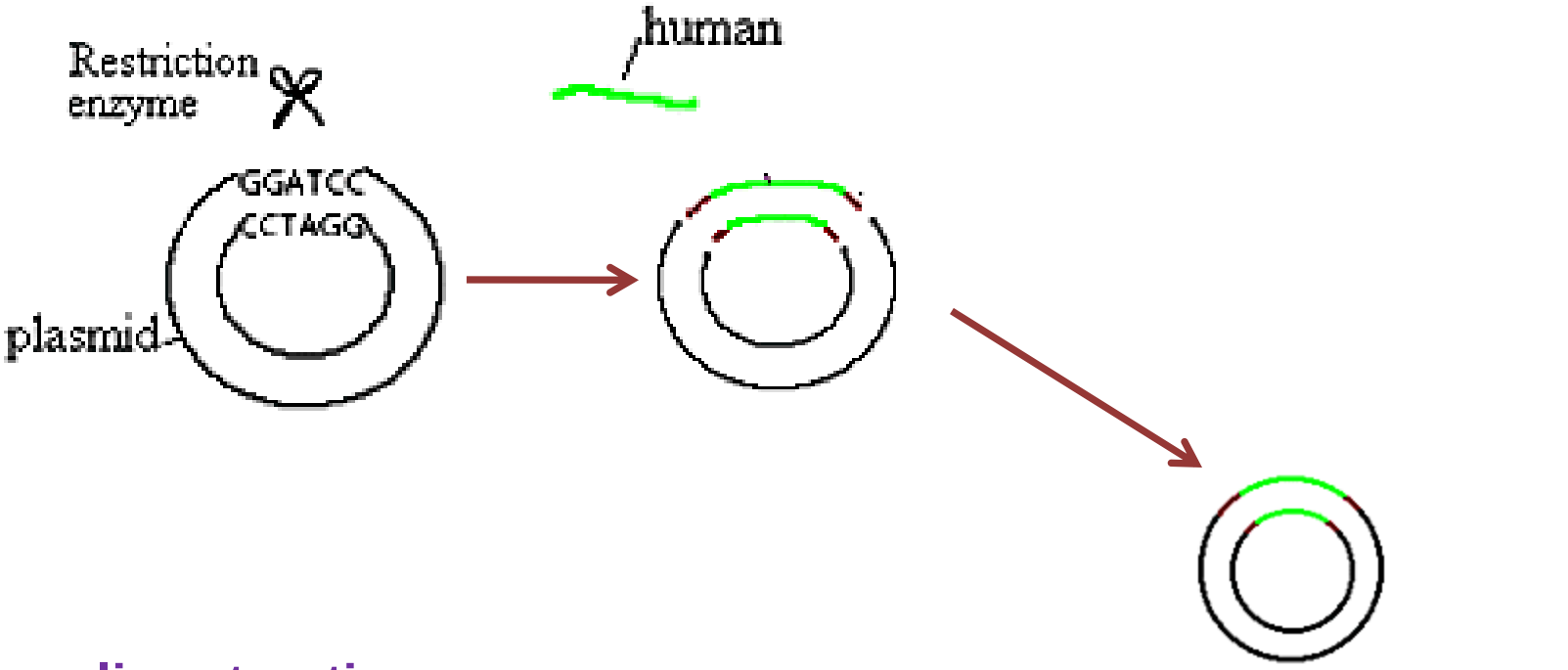


Conclusion:

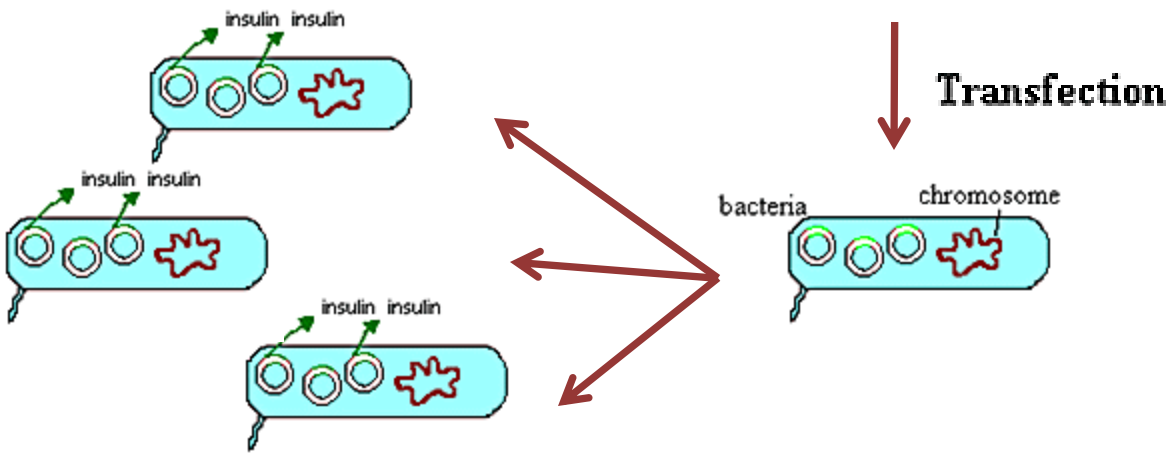
DNA was the transforming factor!

Artificial Transformation

Artificial transformation: Cloning (Example, Insulin production)



Insulin extraction

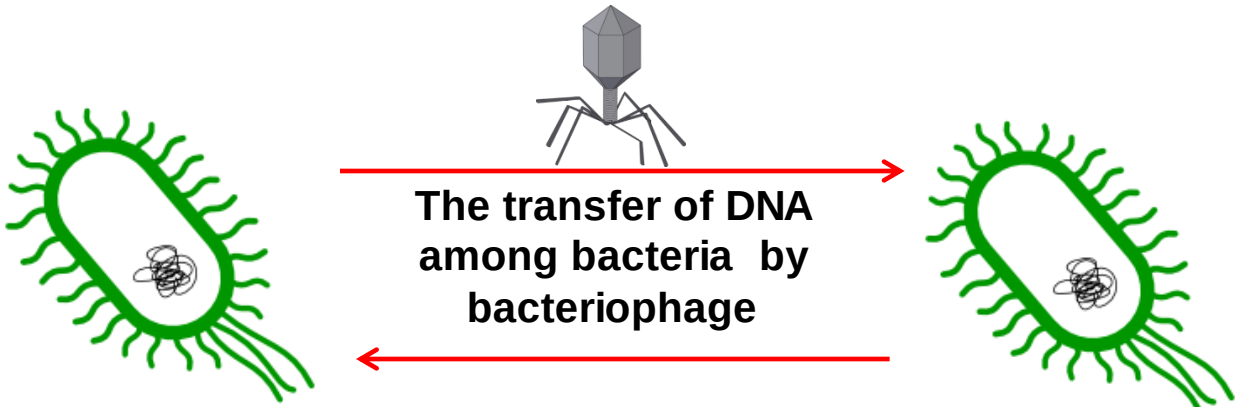


Transduction

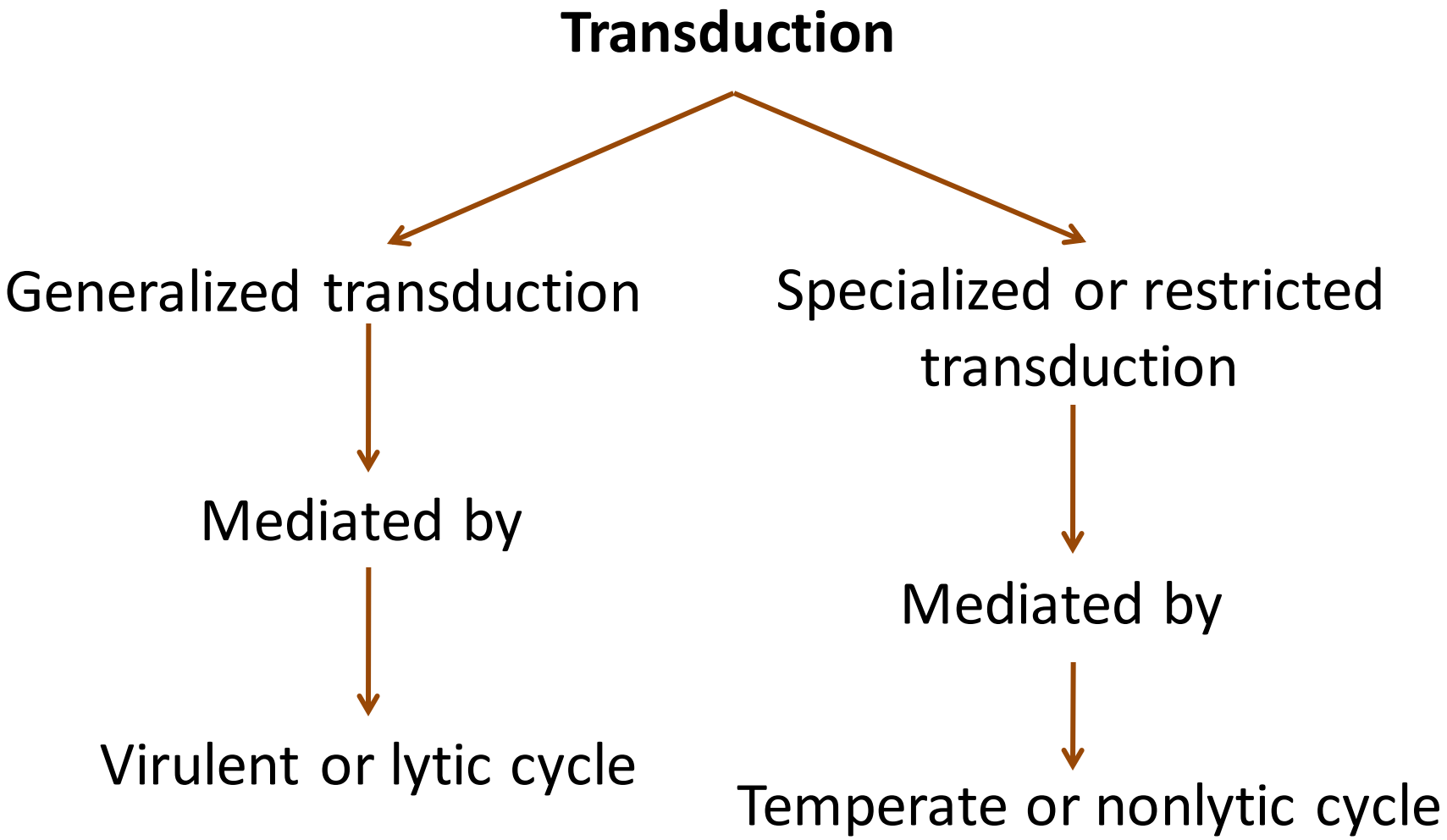
Transduction (means to carry across): Is a bacterial infection by bacteriophages which are viruses that infect and replicate within bacteria

Two types:

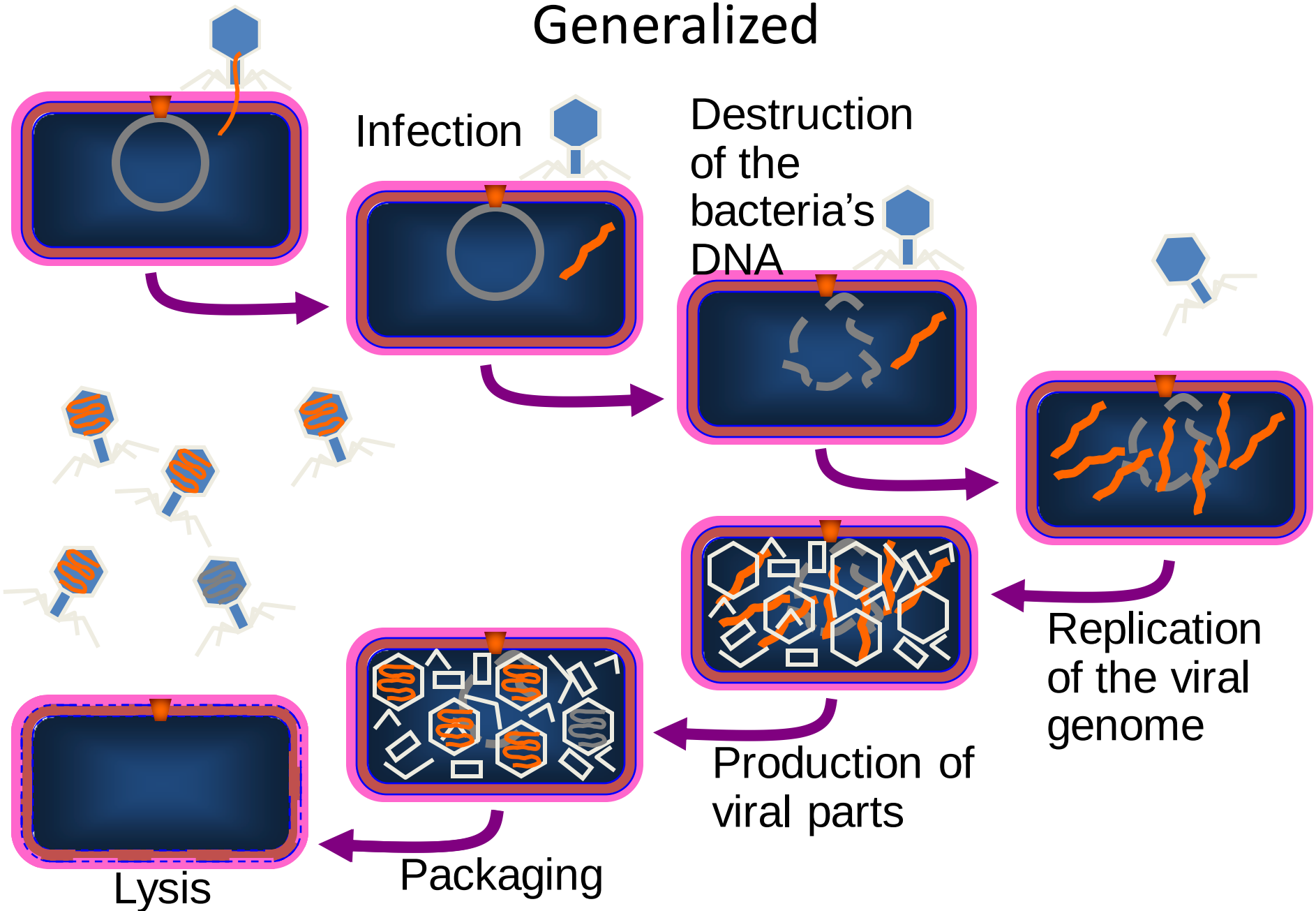
1. Generalized transduction: Since phages of this type pick up any portion of the bacterial chromosome at random are termed generalized transducing phages.
2. Specialized or restricted transduction: A specific bacteriophage transduces only a particular genetic trait.



Transduction



Transduction



Reproduction in Bacteria

Sexual reproduction inbacteria

Specialized transduction:

- Certain bacteria are able to survive (no lysis) for a long time even after infection by bacteriophages
- Herein there is a joining of bacterial DNA with the phage DNA and they replicate together.
- This bacterium is known as lysogenic bacteria and the phage is called as prophage.
- This protein inhibits the synthesis of phage particle inside the bacterial cell.

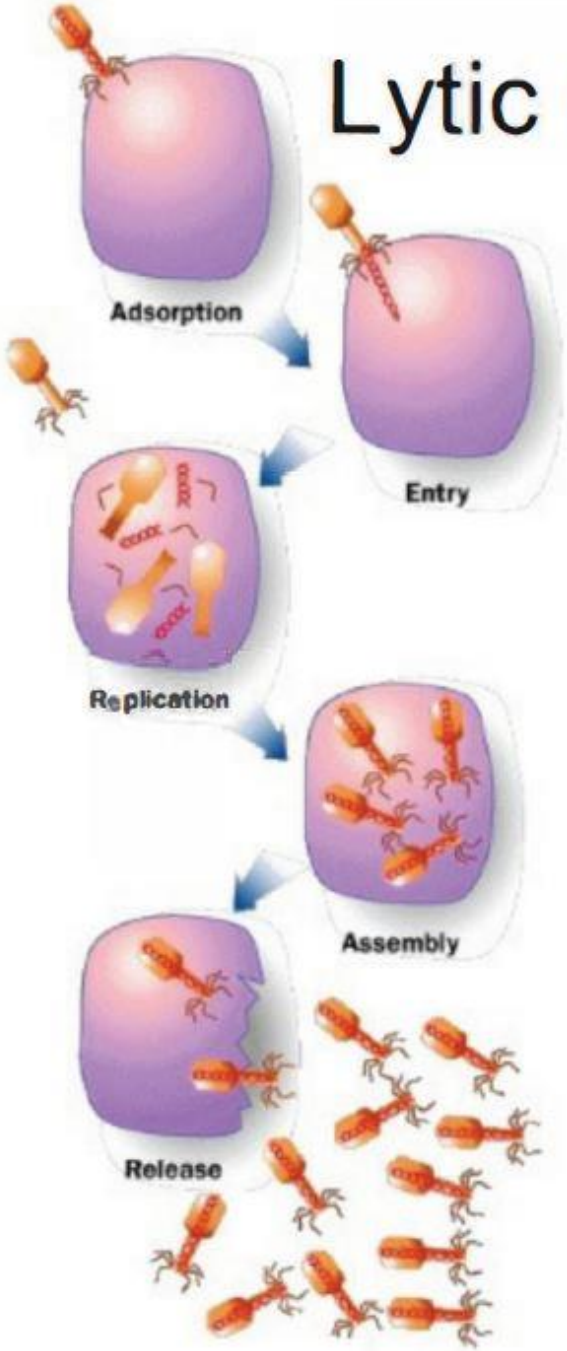
Reproduction in Bacteria

Sexual reproduction inbacteria

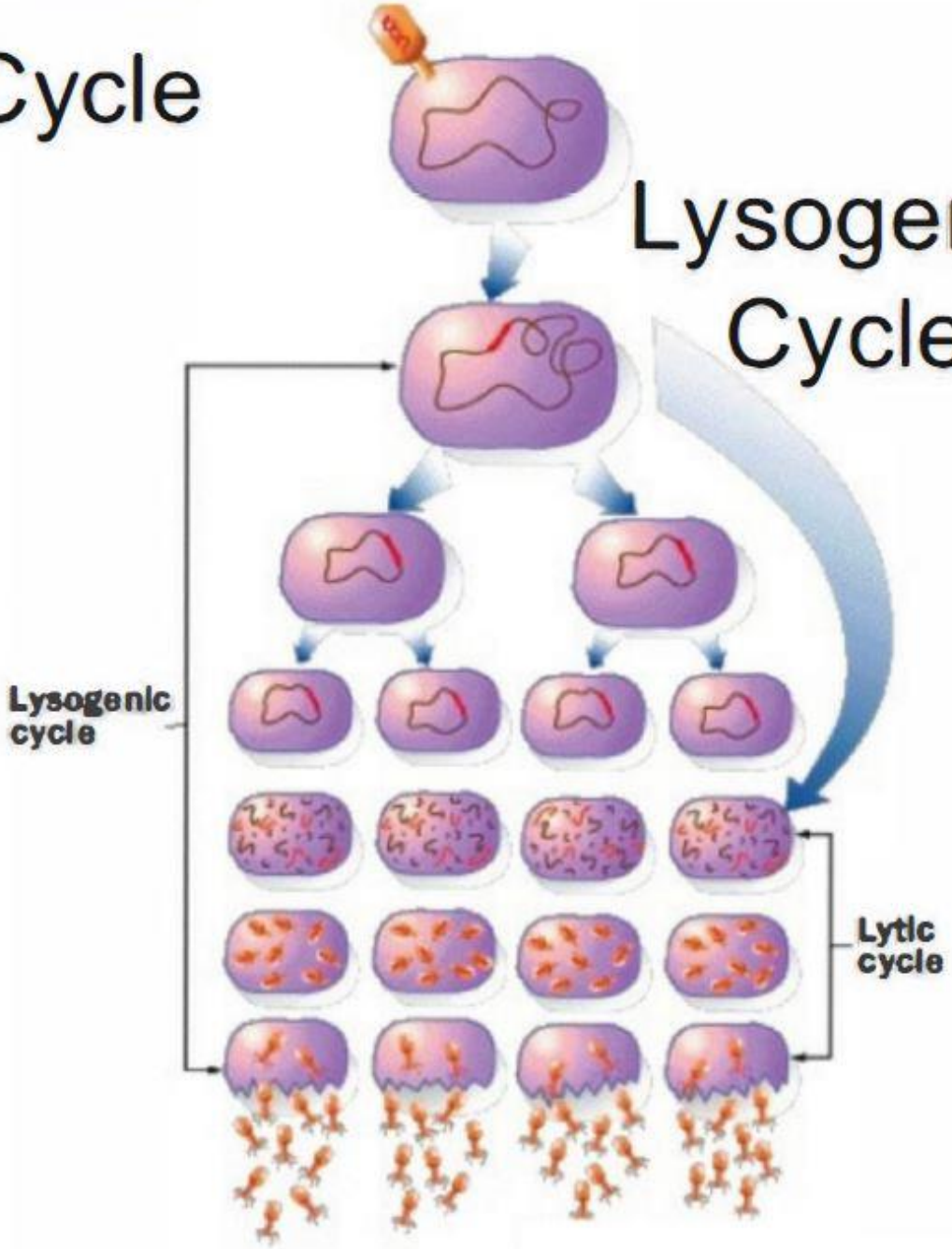
Specialized transduction:

- As the synthesis of this protein is stopped the bacterial cell start the synthesis of phage components.
- The DNA of both i.e. of phage DNA and bacterial DNA breakdown before the synthesis of the phage particles starts.
- At the same time some bacterial genes are carried out by phage DNA and replicate with the phage DNA.
- In this type of transduction only those special genes are transmitted which are attached very closely to the phage DNA.

Lytic Cycle



Lysogenic Cycle

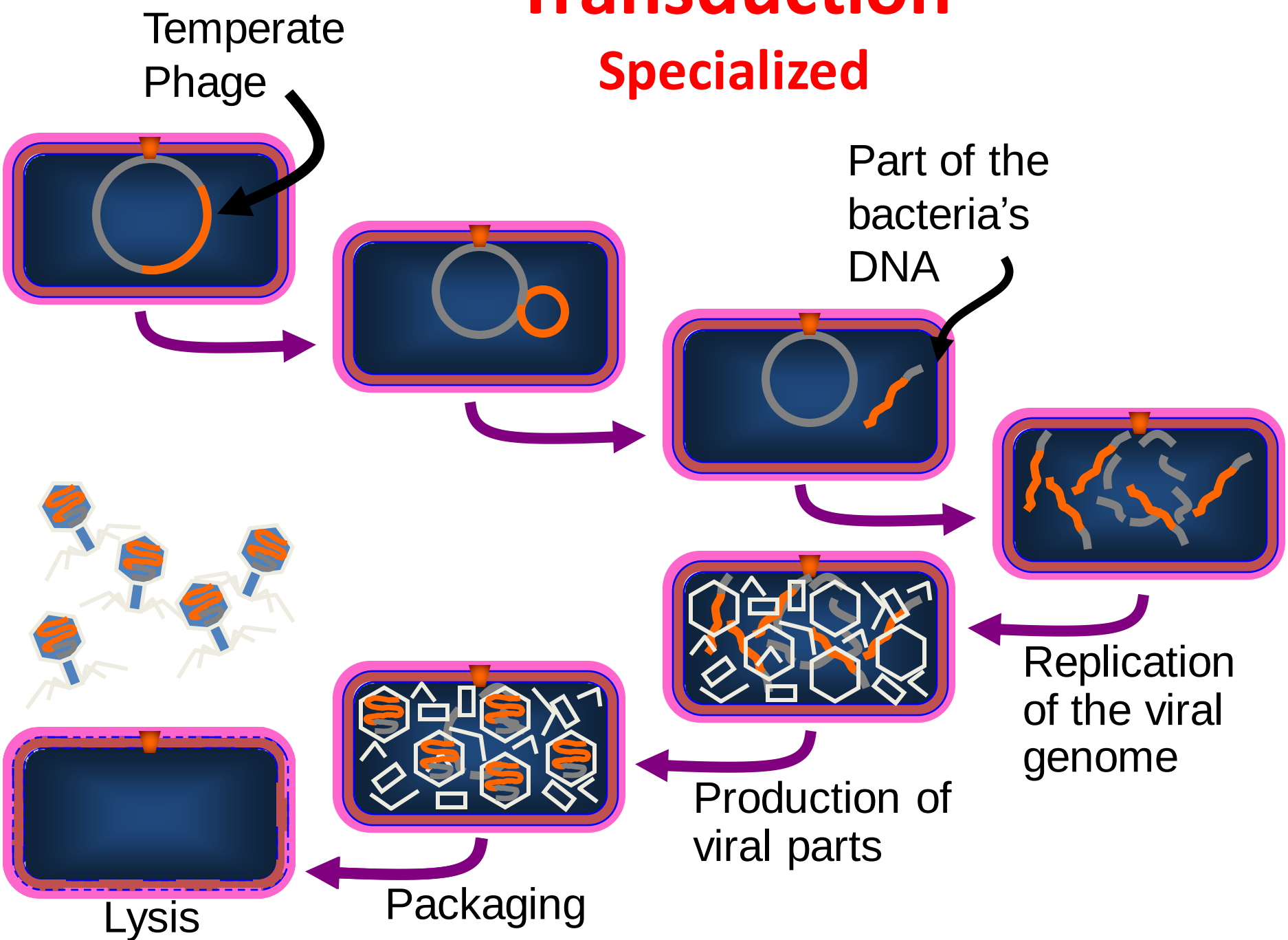


Transduction

1. ***Virulent or lytic cycle:*** large numbers of progeny phages are built up inside the host bacterium, which ruptures to release them.
2. **Temperate or nonlytic cycle:** the host bacterium is unharmed. The phage DNA becomes integrated with the bacterial chromosome as the prophage and is replicated stably as part of the host cell chromosome and is transferred to the daughter cells. This process is called lysogeny and bacteria harbouring prophages are called lysogenic bacteria. In lysogenic bacteria, the prophage behaves as an additional segment of the bacterial chromosome, coding for new characteristic. This process by which the prophage DNA confers genetic information to a bacterium is called lysogenic or phage conversion. In transduction, the phage acts only as a vehicle carrying bacterial genes from one cell to another; but in lysogenic conversion, the phage DNA itself is the new genetic element.

Transduction

Specialized



Transduction

Medical Importance

Bacterium	Phage	Gene Product	Phenotype
Vibrio cholerae	CTX phage	cholerae toxin	cholera
Streptococcus pyogenes	T12	erythrogenic toxins	scarlet fever
Corynebacterium diphtheriae	corynephage beta	diphtheria toxin	diphtheria
Escherichia coli	lambda phage	shigalike toxin	hemorrhagic diarrhea
Clostridium botulinum	clostridial phages	botulinum toxin	botulism (food poisoning)

Reproduction in Bacteria

Sexual reproduction inbacteria

Conjugation:

- Is the commonest process of sexual reproduction in bacteria.
- In conjugation two parental cells physically contact between two genetically different cells of the same or closely related species and transfer their genetic material through a small tube like projection called conjugation tube.
- The genetic material from one cell (donor or male) is transferred to other (recipient or female).

Reproduction in Bacteria

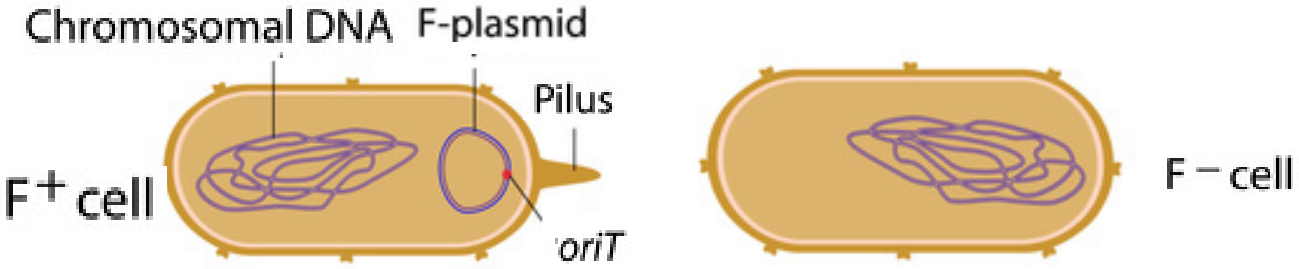
Sexual reproduction inbacteria

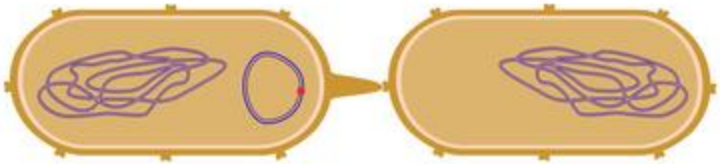
Conjugation

Fertility factor (F factor):

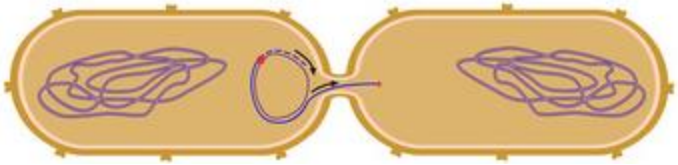
- plasmid trasnfered by conjugation are celled Fertility factor.
- Bacteria are classified in two groups on the basis of presence and absence of F factor. They are as follows :
  i. F+ strain bearing the fertility factor, also known as donor cell. It always bears sex pili or F pili on its surface.
  ii. F- strain lacking the fertility factor, also known as recipient cell. It lacks sex pili or F pili on its surface.

Conjugation

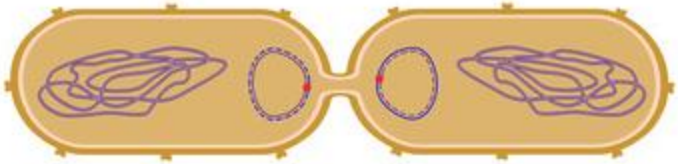




A conjugation tube forms between the donor cell and the recipient cell



A single strand from the plasmid DNA is transferred through the tube from the donor to the recipient.



A double stranded DNA is formed from the single strand in both the donor and the recipient cells.

Conjugation

Medically important factors transferred by conjugation

- Resistance (R) plasmids, which contain genes that provide resistance against antibiotics or poisons.

- colicinogenic (or *Col*) plasmids: determines the production of proteins called colicins (bacteriocins), which have antibiotic activity and can kill other bacteria

Transposons "Jumping Genes"

- **Transposons** are segments of DNA that can move from one location to another in a genome.

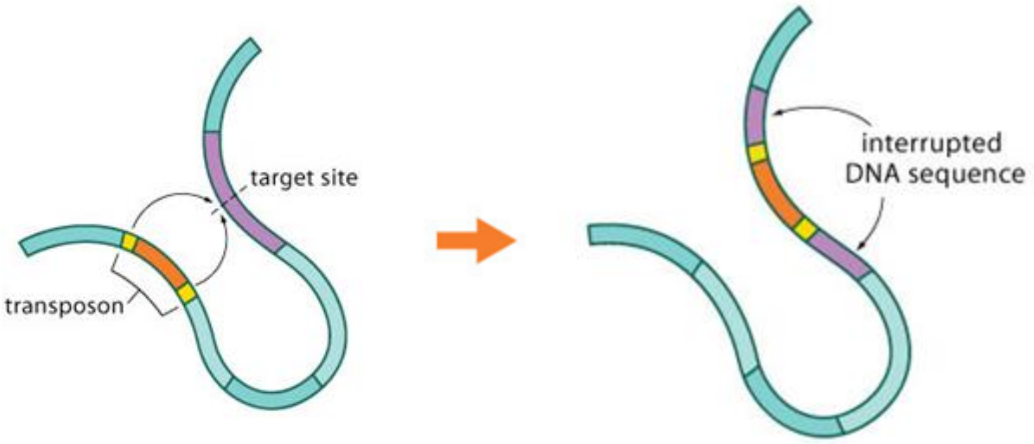
- In bacteria, transposons can move from one location to another on the chromosome, from the chromosome to a plasmid, from a plasmid to the chromosome, or from one plasmid to another.

- In this way, genes can be transferred from one cell to another.

Factors affecting bacterial genes

Transposons "Jumping Genes"

1. Cut-and-paste mechanism



2. Copy-and-paste mechanism