BACTERIAL GENETICS

- Each living organism resembles its ancestors in most of its characters.
- The maintenance of characters over generation is known as" Heredity".

Genetics: concerned with transfer of characters and each genetic character is assigned to a "gene" which carries the information.

Gene: a segment of DNA molecule formed of nucleotide sequence determined biological information carried by gene.

Bacterial Genome: is the total set of genes present inside the bacterial cell including mainly the bacterial chromosome and plasmids (???).

BACTERIAL GENETICS

Operons: cluster of genes coding for a series of enzymes that act in concert in an integrated biochemical pathway as in case of Lac operons of *E. coli*

Multigene Families: a group of identical genes e.g. multiple copies of 5 s rRNA (2000 copies) needed for synthesis of rRNA

Bacterial Chromosome

- The bacterial cell lacks a nuclear membrane; instead DNA is concentrated in the cytoplasm and known as nucleoid (bacterial chromosome).

- The bacterial chromosome is mostly long, closed, single, highly coiled and circular double strand 1.3 mm length.

- It replicates by the semi-conservative method of DNA replication (i.e. the two strands are separated and each strand acts as a template to synthesize a complementary strand).

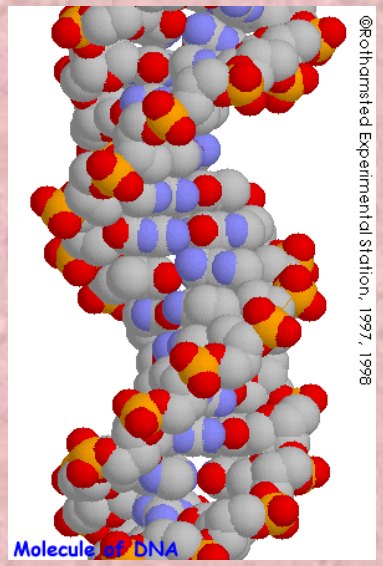
- It also follows the same rules of gene expression and protein synthesis (i.e. transcription & translation) as higher organisms.

Structure of DNA

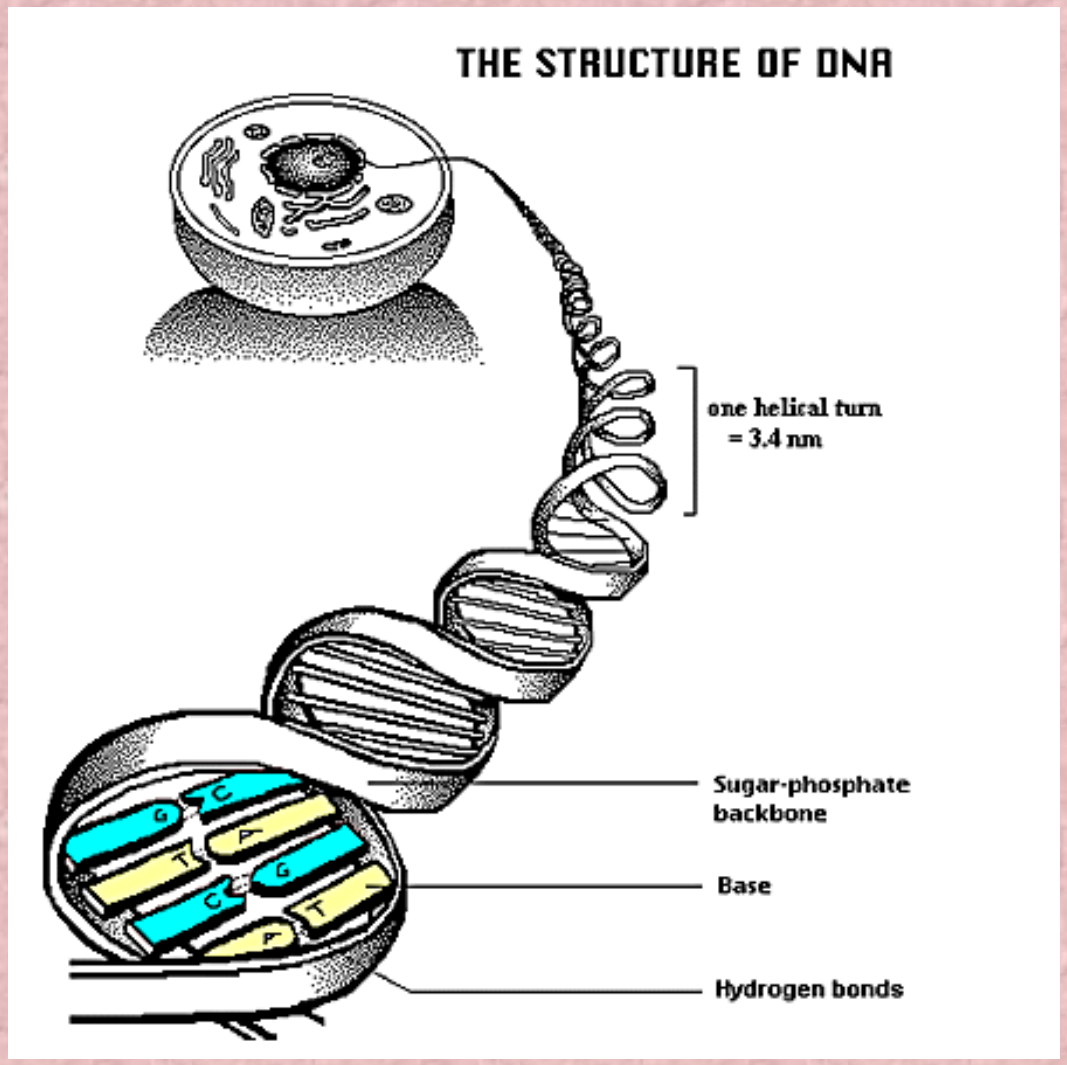
- The chromosomes are composed essentially of DNA, which contains coded instructions for synthesis of every protein in the body. DNA is extremely long, flexible ladder that has been twisted right-handed (like a corkscrew).

- DNA consists of millions of nucleotides within two interlinked, coiled chains. Each nucleotide contains one of four nitrogenous bases (purines; adenine (A) &guanine (G) and the pyrimidines; cytosine (C) and thymine (T) together with one attached deoxyribose sugar and one phosphate group.
- Nucleotides and it is the sequence of these bases that contains the coded instructions.
- Each base on one chain is matched by a complementary partner on the other, and each sequence provides a template for synthesis of a copy of the other. Synthesis of new DNA is called (replication).
- The unit of length of DNA is the base pair (bp) with 1000 bp in a kilobase (kb) and one million base pairs in a megabase (Mb).

Review: The structure of DNA

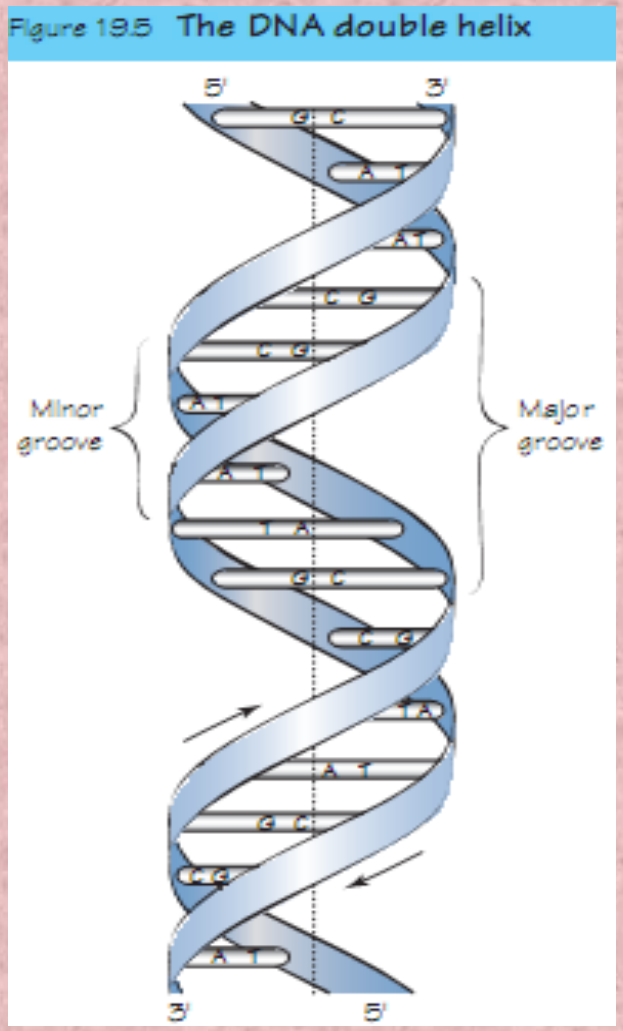


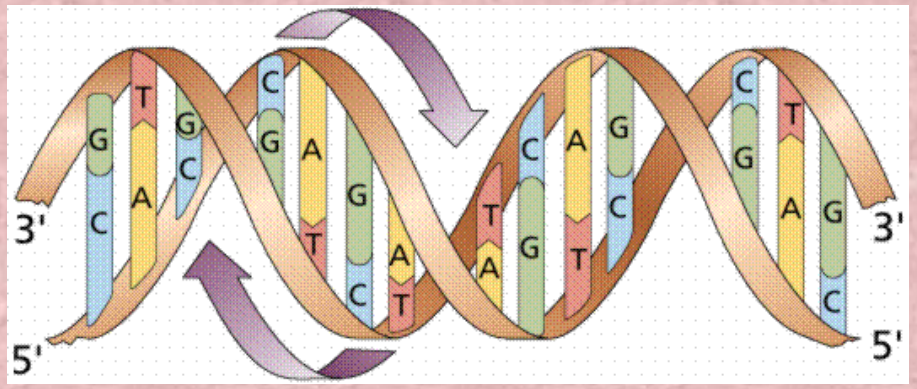
Double Helix



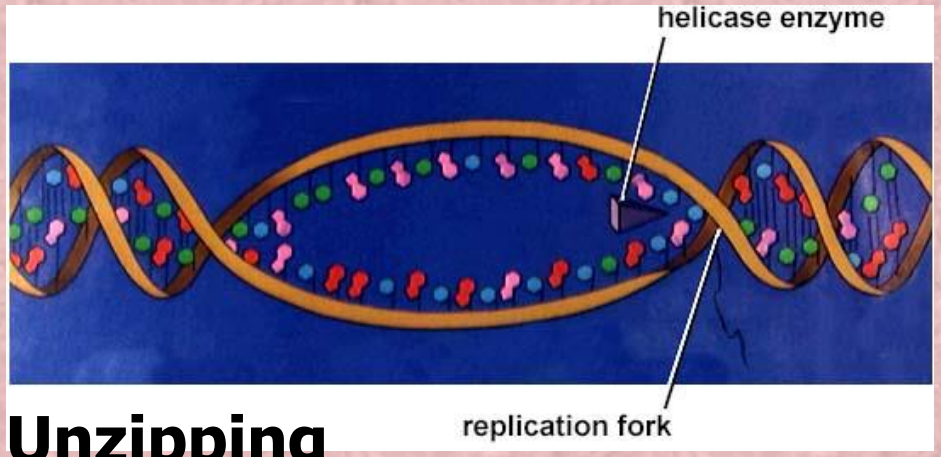
Complementary Base Pairing

Review: The structure of DNA

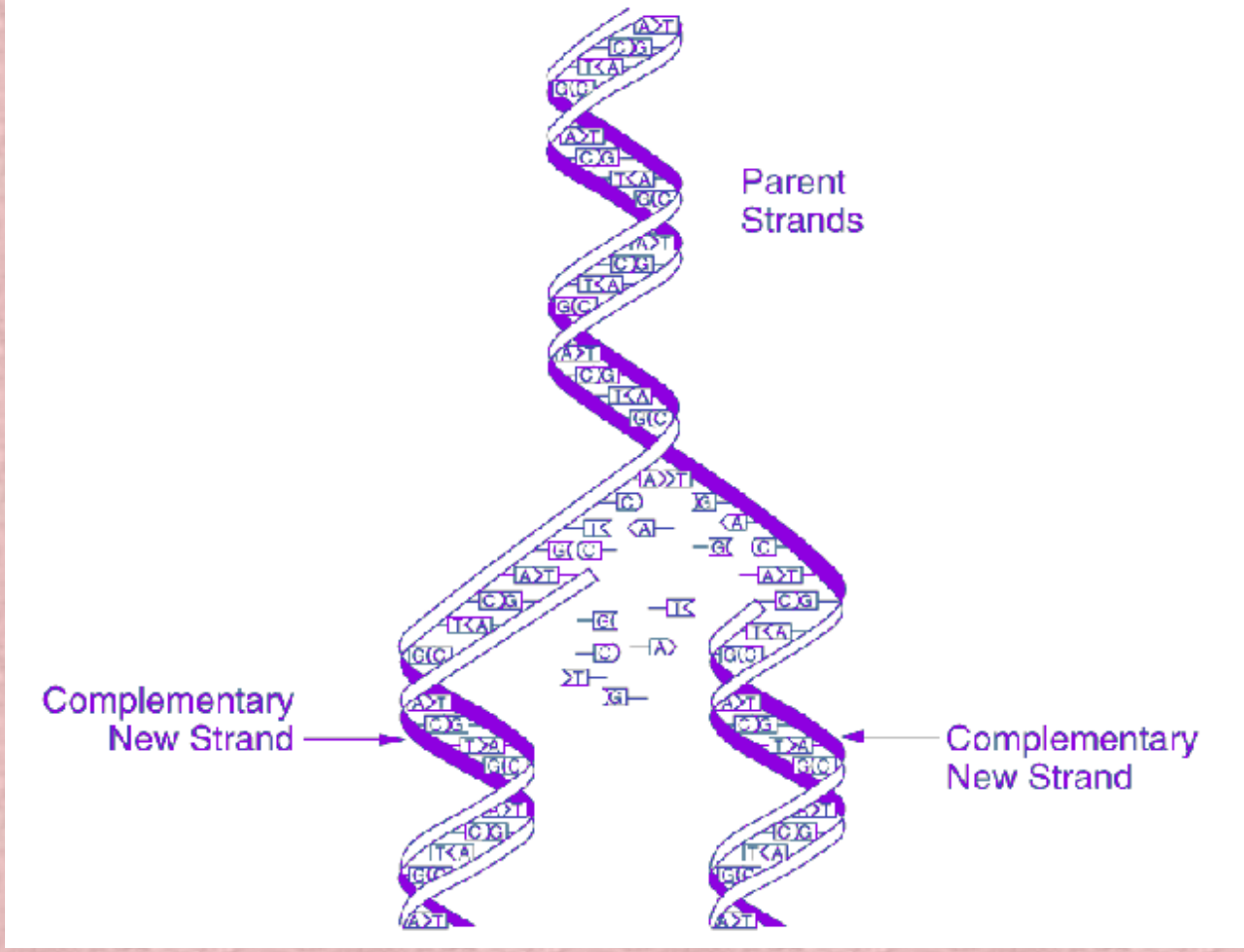




Antiparallel Strands



Unzipping


Parent
Strands
Complementary
New Strand
Complementary
New Strand

Plasmids

- Plasmids are extra chromosomal DNA molecules in the form of double stranded, closed and circular molecule.
- it is smaller than bacterial chromosome.
- It is not responsible for the growth or physiology of bacterial cell.
- It can be easily gained or lost by a bacterium and can be transferred between bacteria as a form of horizontal gene transfer.
- It is responsible for transfer of characters under natural condition inside host; two bacteria transfer plasmid to each other.

Types of Plasmids

1. Conjugative plasmids
2. Non conjugative Plasmids

1. Conjugative plasmids: (F. factors)

Function by coding for factors responsible for conjugation gene between two microorganisms (sex pili, sex pheromones and adhesins).

2. Non conjugative plasmids:

It is responsible for phenotypic character of microorganisms.

A. Bacteriocin coding plasmids:

Some microorganisms produce toxins which inhibit the growth or even kill other microorganisms; these proteins are plasmid coding e.g. Colicins (*E. coli*), pyocins (*P. aeruginosa*) and Megacins (*B. megatium*).

B. Resistance plasmids (R- plasmids):

Responsible for resistance against one or more (up to 8) antibiotics and heavy metals (Mercurochrome).

C. Virulence plasmids:

Some microorganisms get out some toxins from plasmids e.g. enterotoxins and haemolysins in *E. coli*.

Gene Expression (protein synthesize)

- Most metabolic processes are catalysed by proteinaceous enzymes and proteins are also the main structural components of the cell. The amino acid sequences of all proteins are coded in the DNA. Conversion of the DNA-encoded information into protein involves transcription into mRNA (in he presence of RNA polymerase)& translation into polypeptide (protein).

- RNA polymerase is an enzyme formed of a sequence of amino acids formed of several subunits (5 subunits in *E. coli*).

Transcription

The first stage of gene expression, RNA polymerase directs the synthesis of mRNA or the transcript. mRNA is consisted of leader sequence, structural gene and trailer sequence.

•Transcription is divided into three steps; initiation, elongation and termination.)

1. Initiation

✓ It occurs at a certain point along DNA molecule known as attachment point or "Promoter" (short nucleotide sequences). At this point RNA polymerase recognizes the gene to begin transcription.

2. Elongation

✓ RNA polymerase migrates along DNA molecule. Melting and unwinding of double strand molecule and associate ribonucleotides to 3′ end of the growing RNA molecule (mRNA).

3. Termination

✓ At specific nucleotide sequences (after the end of gene) and in the presence of terminator (enzyme), RNA polymerase dissociates from DNA molecule leave the mRNA to release in a process known as "Translation".

Translation

The second and last stage of gene expression in which protein is synthesized.

- Each cell contains different types of tRNA; each type is specific for amino acids.
- The specificity of transferring of correct amino acids (to ensure that the correct tRNA carry correct amino acids) is known as "charging" or "amino acylation" and produced by amino acyl tRNA synthetase.

•Translation is divided into three steps; initiation, elongation and termination)

1. Initiation

- ✓ The ribosome pool in the cell is formed of two subunits; 30s& 50s.
- ✓ The 30s ribosomal subunit is attached to mRNA at specific nucleotide sequence known as "Ribosome binding site"; RBS, beside the start codon of translation.
- ✓ The 30s ribosomal subunit migrates down stream until it reaches AUG codon which is known as "Start codon" or "Initiation codon".
- ✓ mRNA + 30s ribosomal subunit + amino acylated tRNA (carry a.a.) is known as "Initiation complex".

Translation

2. Elongation

- ✓ It starts when amino acylated tRNA enter A site of 50s ribosomal subunit.
- ✓ In the presence of peptidyl transferase enzyme, tRNA is released and at some times the dipeptid is formed and the cycle is repeated.

3. Termination

- ✓ Occurs when one of the following stopping codons "UAA-UAG-UGA" enter A site of 50s ribosomal subunit.
- ✓ One of the two release factors; RF1 or RF2 enters A site to cleave formed polypeptide chain.

Gene Transfer

- Gene can be transferred by three methods; **Transformation**, **Transduction** OR **Conjugation**.
- All of three processes **DNA** (or **part of it**) is transferred from **donor** to **recipient** cell. This process is called as **genetic recombination** or **parasexuality**.
- In this case, **recipient** cell is known as "**Recombinant Bacterium**".

1. Transformation

Gene transfer by soluble DNA which has been liberated or extracted after death of bacteria.
It may occurs naturally or induced.

2. Transduction

Gene transfer by **bacteriophages**.
There are two types:

a. **Generalized (Non specific):** in which any part of DNA can be transferred.

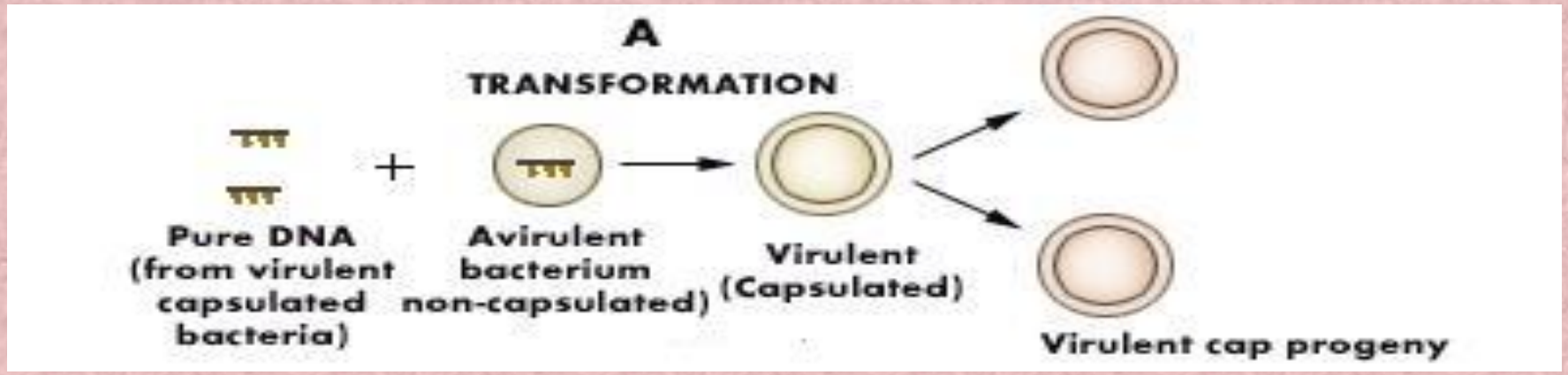
b. **Specific:** in which specific sequence of DNA is transferred.

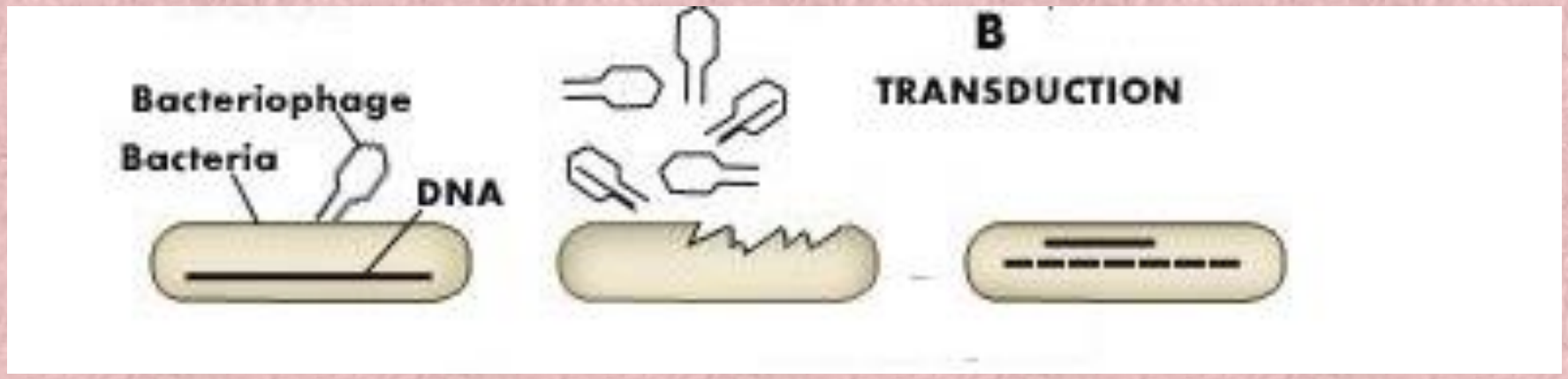
3. Conjugation

Gene transfer by direct contact between two microorganisms is known as "Conjugation".

- It is a process in which the genetic material of a bacterial cell of a particular strain (donor or male) is transferred into that of another bacterial cell of a different strain (recipient or female).

- The donor cells are known to possess a sex factor or fertility factor (F factor) as a component of its circular DNA (F+ strain). The recipient cell does not have this factor (F- strain).


A
TRANSFORMATION
Pure DNA
(from virulent
capsulated
bacteria)
Avirulent
bacterium
non-capsulated)
Virulent
(Capsulated)
Virulent cap progeny


B
TRANSDUCTION
Bacteriophage
Bacteria
DNA


C
CONJUGATION

Mutations

It is Inheritable changes in DNA due to error in DNA during replication or damage to any part of DNA or spontaneous changes in basis the repair enzyme do not correct.

❖ **Types of mutation according to molecular alteration:**

1. Point Mutation

- It is an exchange of individual bases.
- When a purine is exchanged with purine (A→G) OR pyramidine with another pyramidine (C→T); this exchange is known as "Transition".
- The exchange of purine with pyramidine is known as "Transversion".

Product of point mutation

- Production of different protein due to different amino acids production.
- Production of law activity protein due to pre-mature termination of translation (shortage amino acids).
- Polarity: It is occurs due to inactivation of any of the successive genes along mRNA, when a stop codon is formed.

Mutations

2. Deletion and Insertions

- It means Removal Or Insertion of one or more bases into DNA molecule

Product of Deletion and Insertion mutation

Either inactivation of one or several genes OR production of law activity protein.

3. Frame shift mutation

- It is considered a specific type of deletion and insertion mutation where changes occur in one base only.

Product of Frame shift mutation

Production of law activity protein

Mutagenic agents

These are materials which lead to induction of mutation.

1. Radiation: X-rays and radio active particles cause damage in DNA molecule.

2. Chemicals Some materials such as hydroxyl amine which makes deamination (deaminate A, C, G) and NO_2 (deaminate G).

3. Inter calating agents: Acridine dyes: materials that have ability to enter, inserts itself between neighboring bases increasing distance between them.

Transposons (Tn elements)

These are short non autonomously replicating DNA sections mainly (2000 bp) used for induction of insertion mutation. It need a carrier or rector for transmission between bacterial cells (e.g. bacteriophage).

- It can jump or move along the DNA molecule.
- It is responsible for resistance against one or more of antibiotics.

Thank You