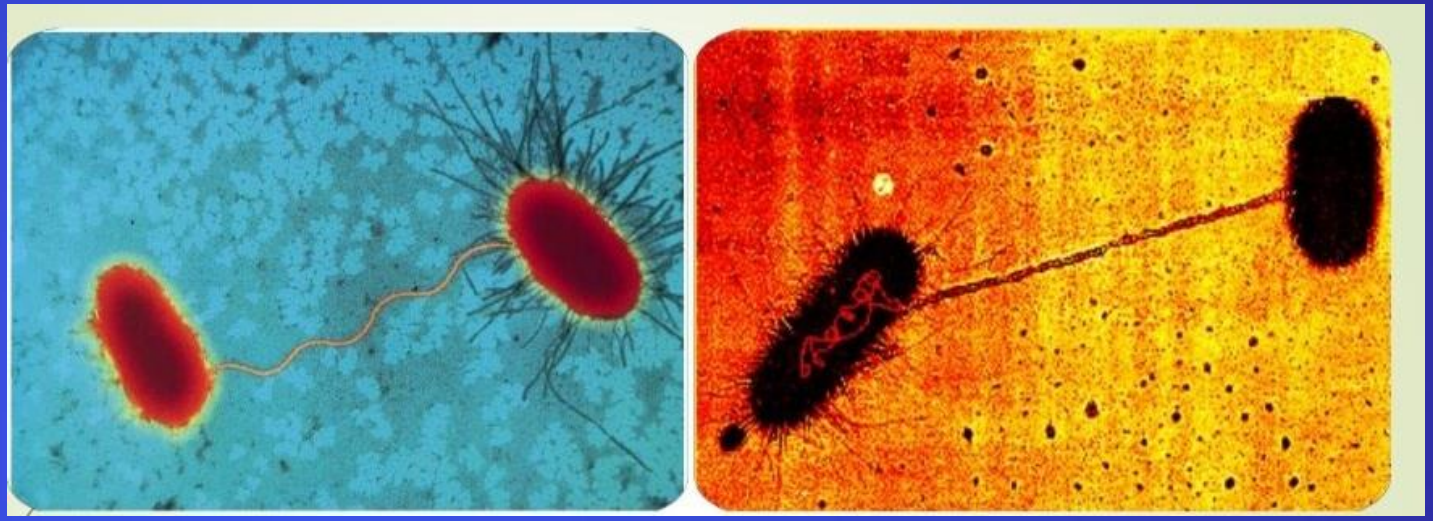
به نام خدا

Bacterial Genetics



استاد:

دکتر فاطمه فردصانعی

Introduction

1. The bacterial genome is the total collection of genes carried by a bacterium(chromosome and on its extrachromosomal genetic elements

2. Bacteria usually have only one copy of their chromosomes (they are therefore haploid)

3. only one chromosome, alteration of a bacterial gene (mutation) will have a more obvious effect on the cell.

4. Bacterial genome consist of a circular double-stranded DNA (dsDNA) molecule.

5. The two strands run antiparallel, , with the 5′ of one strand opposed to the 3′ terminal of the other. The strands are also complementary

Basic Principle

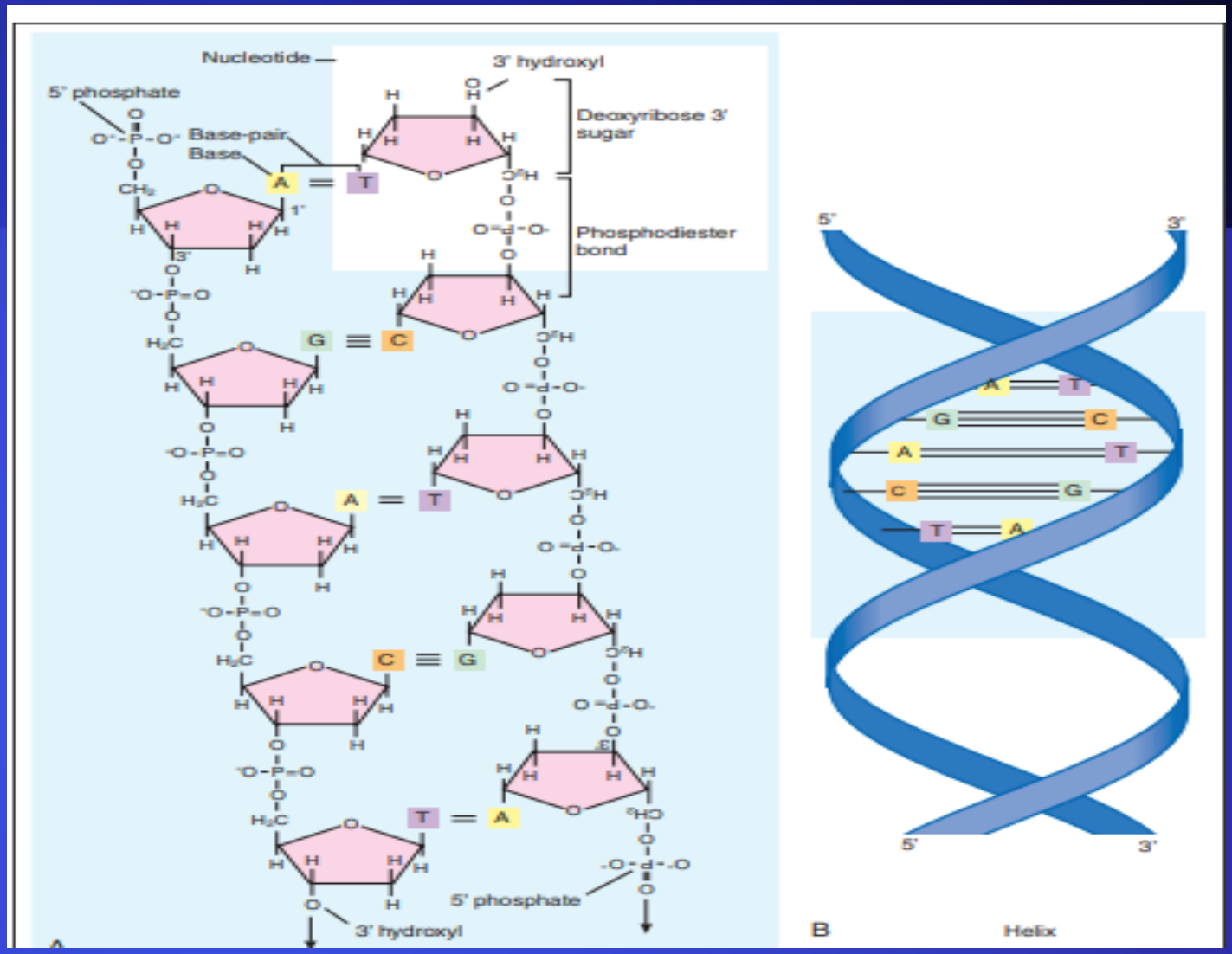
1. DNA consists of deoxyribose sugars connected by phosphodiester bonds.

2. The bases that are covalently linked to each deoxyribose sugar are the key to the genetic code within the DNA molecule.

3. The four nitrogenous bases include two purines, adenine (A) and guanine (G), and the two pyrimidines, cytosine (C) and thymine (T).

4. The combined sugar, phosphate, and a base form a single unit referred to as a nucleotide. guanine triphosphate [GTP], cytosine triphosphate [CTP].

5. In RNA, uracil replaces thymine and ribose sugar replaces deoxyribose.


Nucleotide
3' hydroxyl
5' phosphate
Base-pair
Base
Deoxyribose 3' sugar
Phosphodiester bond
A
T
G
C
5' phosphate
3' hydroxyl
A
5'
3'
Helix

Terms

- Genes
- A DNA sequence that encodes for a specific product is defined as a gene.
- All the genes in an organism comprise the organism's genome.
- The size of a gene and an entire genome is usually expressed in the number of base pairs (bp) present.(KB or MB).
- The genome is organized into discrete elements known as chromosomes

- Codon
- Genetic information stored in DNA as code.
- The code consists of triplets of nucleotide bases, referred to as codons;
- each codon encodes for a specific amino acid

DNA
A Complex Structure Makes Life

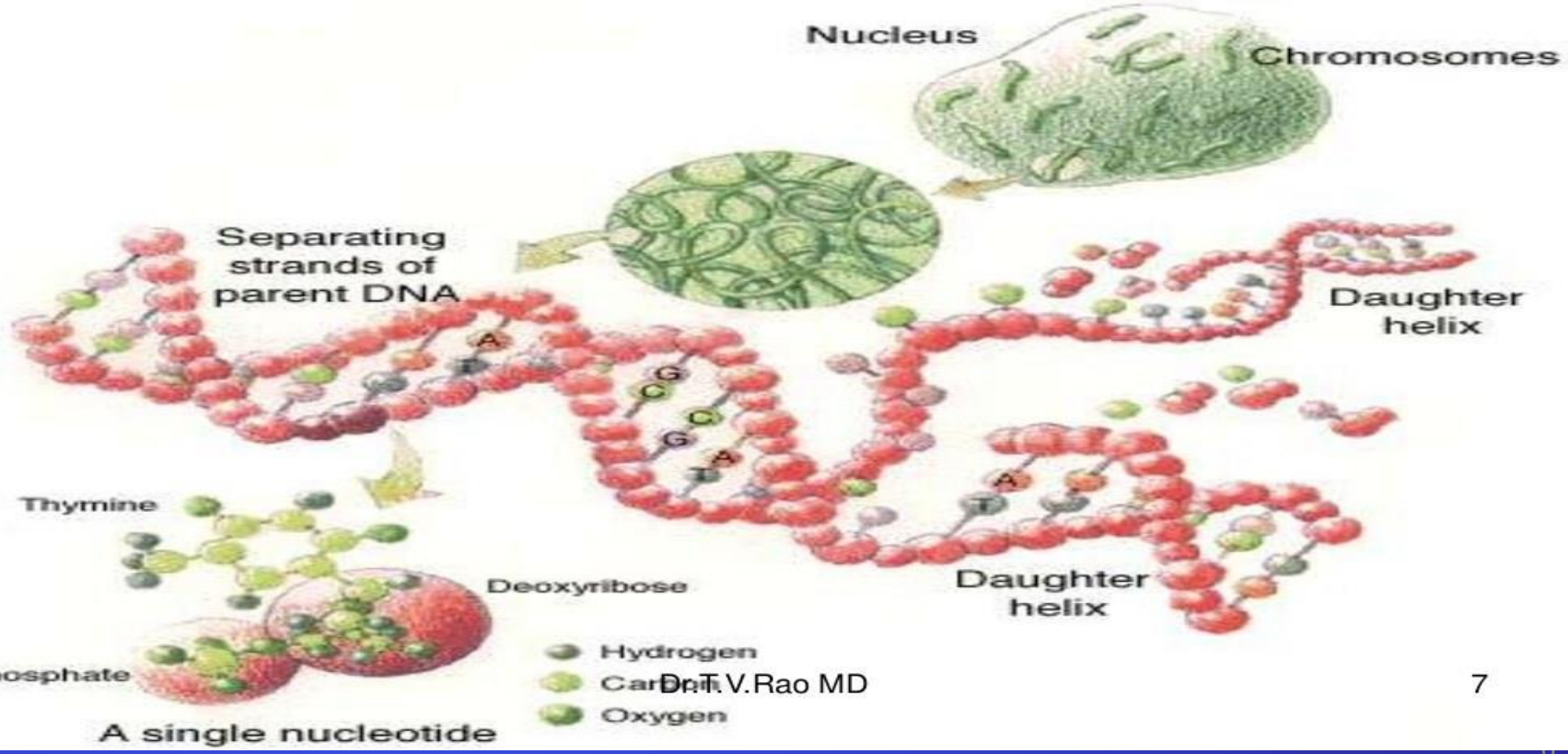


TABLE 2-1 The Genetic Code as Expressed by Triplet-Base Sequences of mRNA*

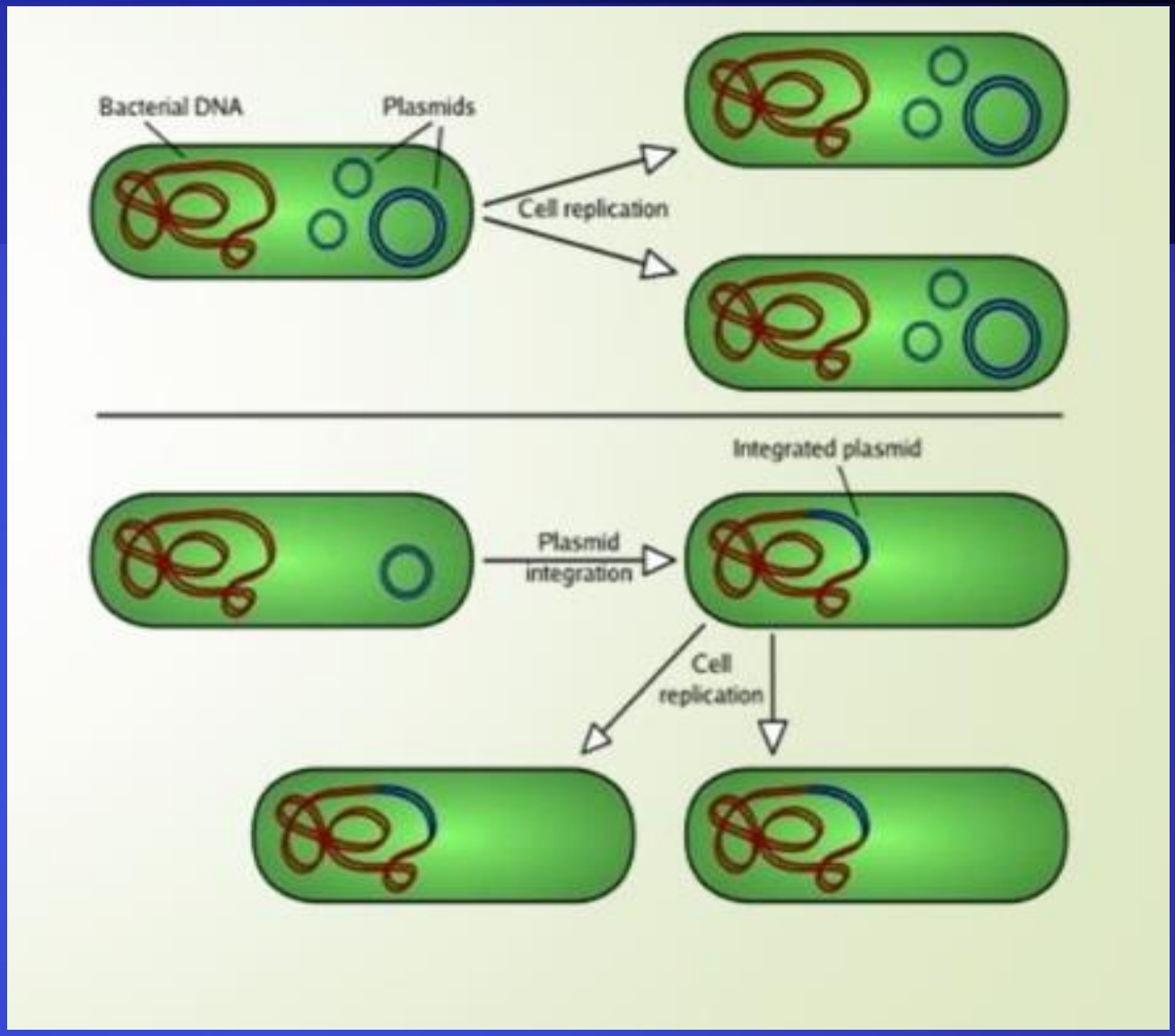
Codon	Amino acid	Codon	Amino acid	Codon	Amino acid	Codon	Amino acid
UUU	Phenylalanine	CUU	Leucine	GUU	Valine	AUU	Isoleucine
UUC	Phenylalanine	CUC	Leucine	GUC	Valine	AUC	Isoleucine
UUG	Leucine	CUG	Leucine	GUG	Valine	AUG (start)†	Methionine
UUA	Leucine	CUA	Leucine	GUA	Valine	AUA	Isoleucine
UCU	Serine	CCU	Proline	GCU	Alanine	ACU	Threonine
UCC	Serine	CCC	Proline	GCC	Alanine	ACC	Threonine
UCG	Serine	CCG	Proline	GCG	Alanine	ACG	Threonine
UCA	Serine	CCA	Proline	GCA	Alanine	ACA	Threonine
UGU	Cysteine	CGU	Arginine	GGU	Glycine	AGU	Serine
UGC	Cysteine	CGC	Arginine	GGC	Glycine	AGC	Serine
UGG	Tryptophan	CGG	Arginine	GGG	Glycine	AGG	Arginine
UGA	None (stop signal)	CGA	Arginine	GGA	Glycine	AGA	Arginine
UAU	Tyrosine	CAU	Histidine	GAU	Aspartic	AAU	Asparagine
UAC	Tyrosine	CAC	Histidine	GAC	Aspartic	AAC	Asparagine
UAG	None (stop signal)	CAG	Glutamine	GAG	Glutamic	AAG	Lysine
UAA	None (stop signal)	CAA	Glutamine	GAA	Glutamic	AAA	Lysine

*The codons in deoxyribonucleic acid (DNA) are complementary to those given here. Thus U is complementary to the A in DNA, C is complementary to G, G to C, and A to T. The nucleotide on the left is at the 5′-end of the triplet.
†AUG codes for N-formylmethionine at the beginning of messenger ribonucleic acid (mRNA) in bacteria.
Modified from Brock TD, Madigan M, Martinko J, et al, editors: *Biology of microorganisms*, Upper Saddle River, NJ, 2009, Prentice Hall.

Extra Chromosomal Genetics elements

- Plasmid

1. small genetic elements that replicate independently of the bacterial chromosome.
2. circular double-stranded DNA molecules varying from 1500 to 400,000 base pairs.
3. plasmids can autonomously replicate(replicon)
4. Episomes, which means they can integrate into the host chromosome.
5. Plasmids carry genetic information that may not be essential but can provide a selective. advantage to the bacteria.


Bacterial DNA
Plasmids
Cell replication
Integrated plasmid
Plasmid integration
Cell replication

Bacteriophages

1. bacterial viruses with a DNA or RNA genome

2. extra chromosomal genetic elements can survive outside of a host cell and be transmitted from one cell to another.

3. Bacteriophages infect bacterial cells and either replicate to large numbers and cause the cell to lyse (lytic infection).

4. integrate into the host genome without killing the host (the lysogenic state) such as the E. coli bacteriophage lambda.
5.
6. Some lysogenic bacteriophages carry toxin genes (e.g., corynephage beta carries the gene for the diphtheria toxin).

Transposon

1. mobile genetic elements that can transfer DNA within a cell, from one position to another in the genome, or between different molecules of DNA (e.g., plasmid to plasmid or plasmid to chromosome).

2. Present in prokaryotes and eukaryotes.

3. Simplest transposons are called insertion sequences and range in length from 150 to 1500 base pairs.

4. with inverted repeats of 15 to 40 base pairs at their ends and the minimal genetic information necessary for their own transfer (i.e., the gene coding for the transposase).

5. such as genes that provide resistance against antibiotics

Pathogenicity or virulence island

1. Some pathogenic bacteria a use a transposon-like mechanism to coordinate expression of a system of virulence factors.

2. the genes for the activity may be grouped together in a pathogenicity or virulence island surrounded by transposon-like mobile elements, allowing them to move within the chromosome and to other bacteria.

3. Genetic unit can be triggered by an environmental stimulus (e.g., pH, heat, contact with the host cell surface) as a way of coordinating the expression of a complex process.

Genetic Exchange and Diversity

- Bacteria multiply by simple binary cell division in which two identical daughter cells result by division of one parent cell.

- Each daughter cell receives the full genetic complement contained in the original parent cell.

- Genetic alterations and diversity in bacteria are accomplished
- by three basic mechanisms:
- mutation
- Genetic recombination,
- Genetic exchange between bacteria

Mutation

1. A mutation is any change in the base sequence of the DNA.

2. A single base change can result in a transition in which one purine is replaced by another purine or in which a pyrimidine is replaced by another pyrimidine.

3. Transversion in which, for example, a purine is replaced by a pyrimidine and vice versa may also result.

4. A silent mutation is a change at the DNA level that does not result in any change of amino acid in the encoded protein.

- A missense mutation results in a different amino acid being inserted in the protein (conservative mutation).

- A nonsense mutation changes a codon encoding an amino acid to a stop codon.

- Conditional mutations, such as temperature-sensitive mutations, may result from a conservative mutation that changes the structure or function of an important protein at elevated temperature.

frameshift mutation

- A small deletion or insertion that is not in multiples of three produces a frameshift mutation.
- This results in a change in the reading frame, usually leading to a useless peptide and premature truncation of the protein .
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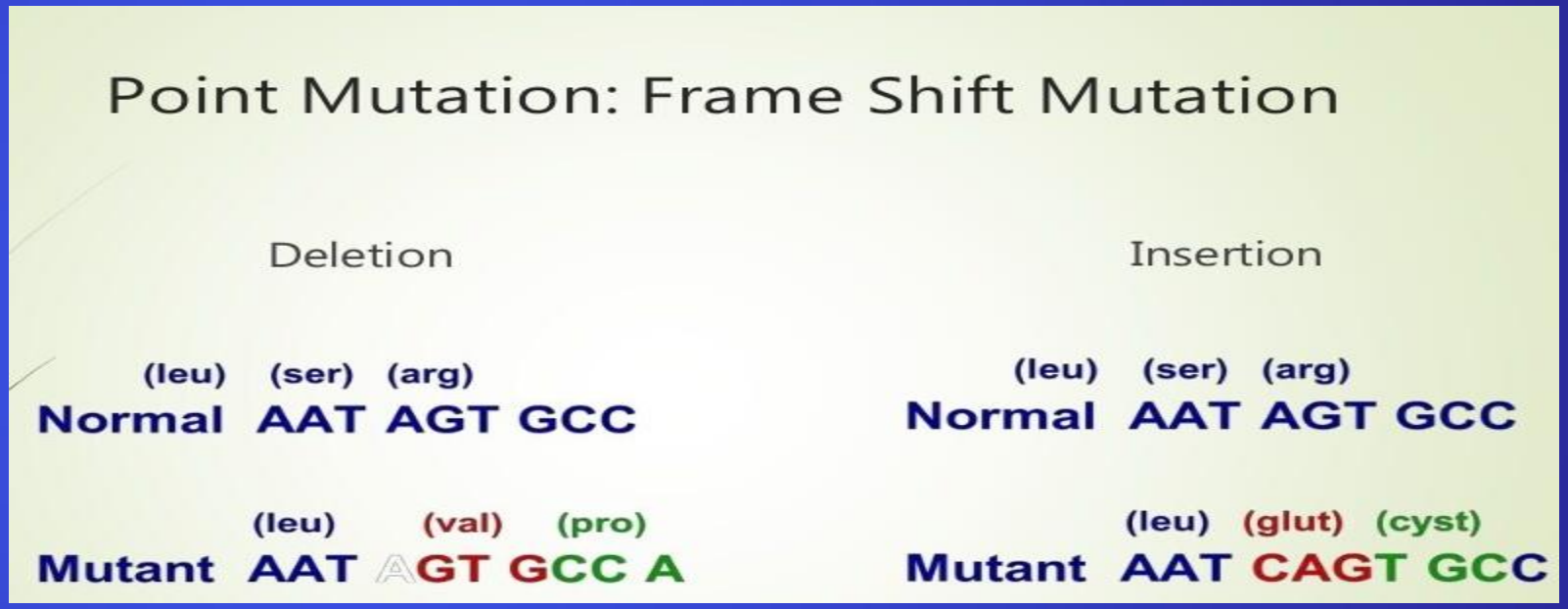


Null mutations

- which completely destroy gene function.

- arise when there is an :

1. extensive insertion,
2. deletion,
3. or gross rearrangement of the chromosome structure.

- Insertion of long sequences of DNA (many thousands of base pairs) by recombination, by transposition, or during genetic engineering can produce null mutations

Genetic Exchange

1. Transformation

- The first mechanism of genetic transfer to be discovered in bacteria

- The process by which bacteria take up fragments of naked DNA and incorporate them into their genomes.

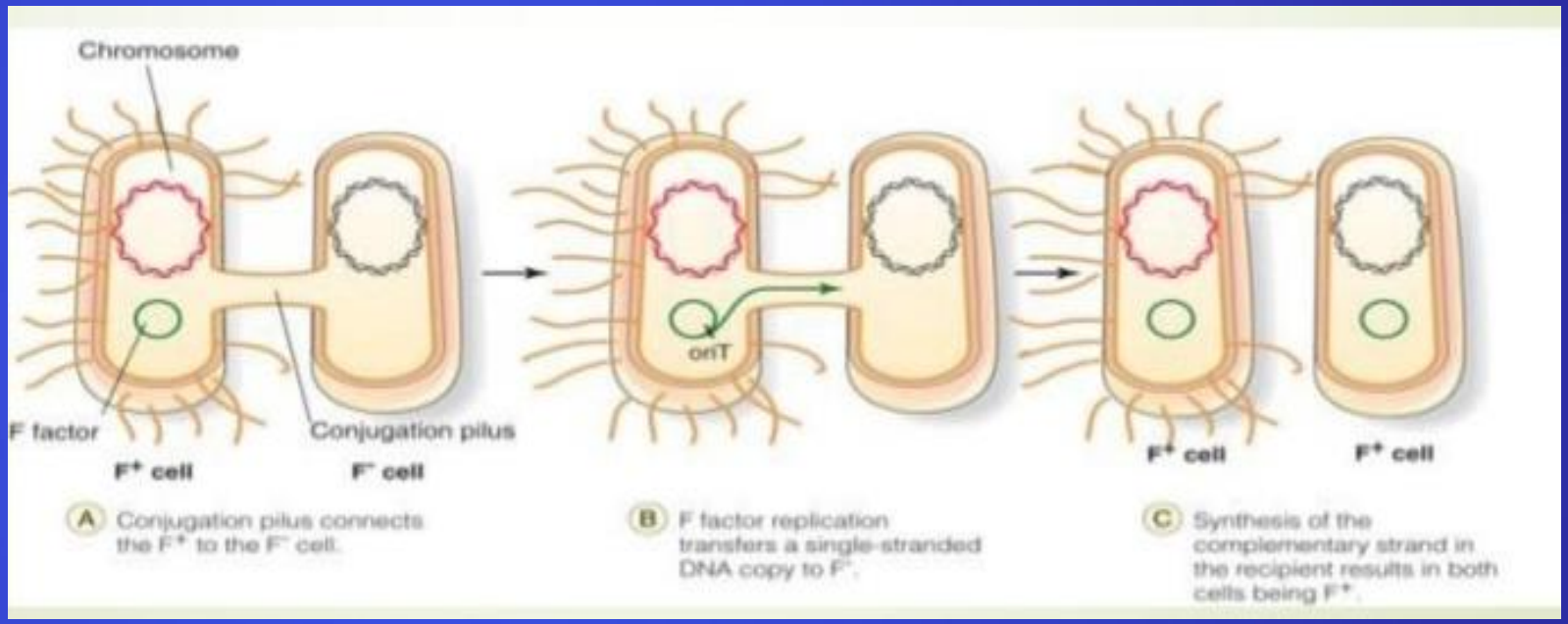
- Certain species are naturally capable of taking up exogenous DNA (such species are then said to be competent), including
- *Haemophilus influenzae*,
- *Streptococcus pneumoniae*,
- *Bacillus spp.*,
- *and Neisseria sp*p.

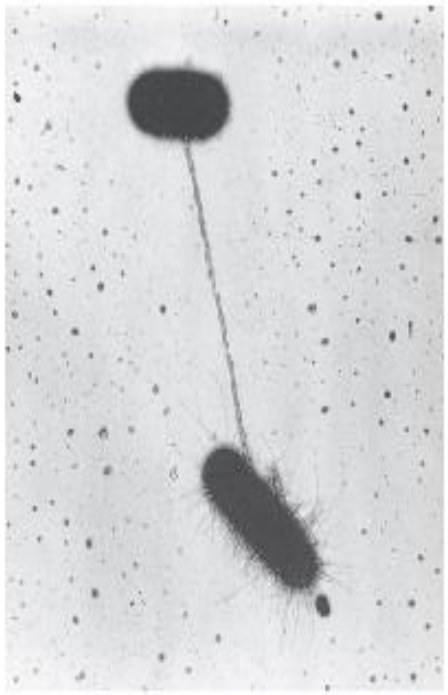
- Chemical methods or electroporation (use of high-voltage pulses) to facilitate uptake of plasmid and other DNA.

Conjugation

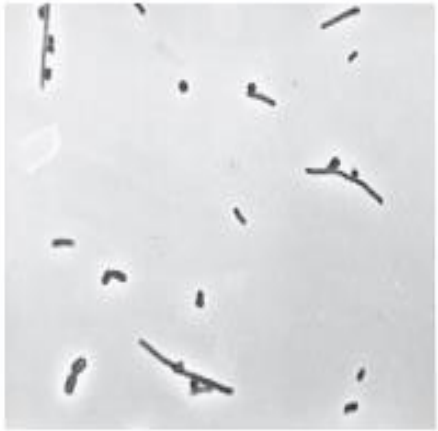
- one-way transfer of DNA from a donor (or male) cell to a recipient (or female) cell through the sex pilus.
- Conjugation occurs with most, if not all, eubacteria and usually between members of the same or related species.
- the mating type (sex) of the cell depends on the presence (male) or absence (female) of a conjugative plasmid, such as the F plasmid of E. coli.
- The F plasmid is defined as conjugative because it carries all the genes necessary for its own transfer, including the ability to make sex pili

- On transfer of the F plasmid, the recipients become F+ male cells.
- The DNA that is transferred by conjugation is not a double helix; rather, it is a single-stranded molecule





A



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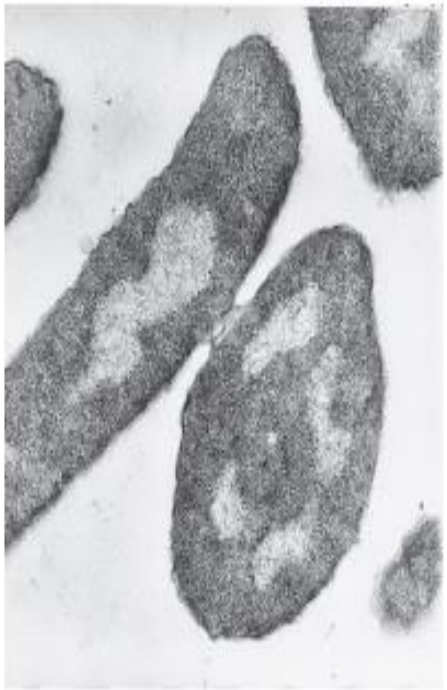
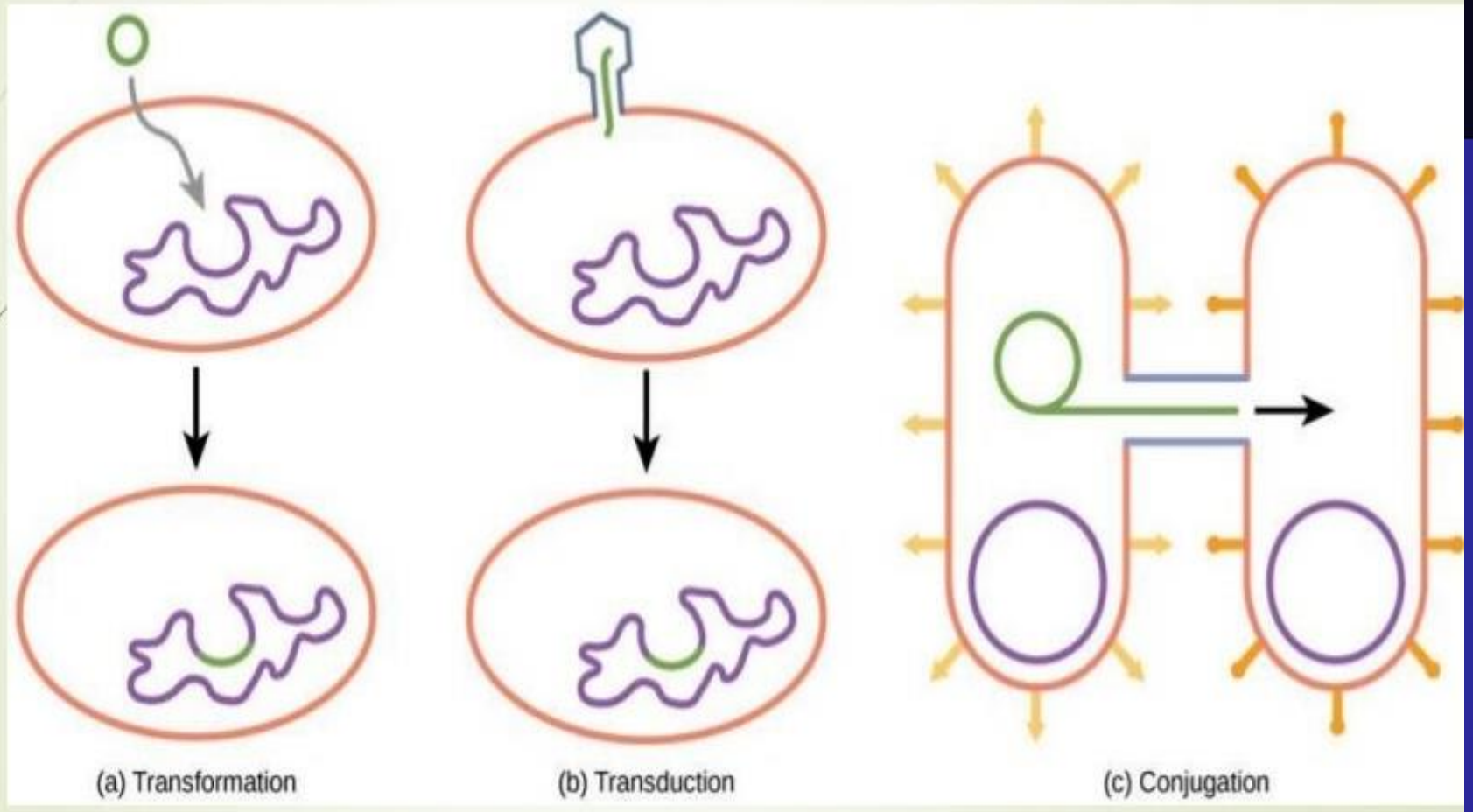


C

Transduction

- Genetic transfer by transduction is mediated by bacterial viruses (bacteriophages) .
- pick up fragments of DNA and package them into bacteriophage particles.
- The DNA is delivered to infected cells and becomes incorporated into the bacterial genomes.
- specialized if the phages in question transfer particular genes (usually those adjacent to their integration sites in the genome) .
- generalized if incorporation of DNA sequences is random



RECOMBINATION

- Incorporation of extrachromosomal (foreign) DNA into the chromosome occurs by recombination.

- Homologous (legitimate) recombination
- Occurs between closely related DNA sequences and generally substitutes one sequence for another.
- The process requires a set of enzymes

- Nonhomologous (illegitimate) recombination
- occurs between dissimilar DNA sequences and generally produces insertions, or deletions, or both.