# Lecture 1

Bacterial Structure and Genetics

- Additional Notes
- Important
- Explanation
- Examples

microbiology433@gmail.com

# OBJECTIVES:

- Define the cellular organization of bacteria and know the differences between Eukaryotes and Prokaryotes.
- Know major structures of bacteria and its functions.
- Cell wall of bacteria including ; chemical structure , the differences between Gram positive and Gram negative bacteria and understand various functions of the cell wall.
- Know short encounter on the bacteria with defective cell wall.
- Know the external structures of bacteria with regards to its structure and function ( flagella, pili and capsule ).
- Know the cytosol and internal structures of bacteria including ; cytoplasmic membrane ,nucleoid, ribosomes and cytoplasmic inclusions.
- Describe bacterial spores , its chemical structure, function, types and its application in the practice of medicine.
- Know basic information on bacterial genetics and the meaning of different terminologies.
- Know the types of bacterial DNA (chromosomal and extra-chromosomal DNA).
- Know brief information on replication of bacteria and bacterial cell division.
- Define plasmids, its origin , types and importance
- Recalls genetics variations, including ; mutation methods of gene transfer and transposon.
- Application on bacterial resistance to antimicrobial agents.

# Differences between Eukaryotic and Prokaryotic cells:

| Prokaryotic cell | Eukaryotic cell |
| --- | --- |
| ▪ Size 1-10 µm | ▪ Size 10 – 100 µm |
| ▪ Always unicellular | ▪ Often multicellular |
| ▪ Has only one chromosome | ▪ Has more than one chromosome |
| ▪ No nucleus | ▪ Central nucleus |
| ▪ Small ribosomes | ▪ Larger ribosomes |
| ▪ No membranous organelles such as: mitochondria, Golgi apparatus,…etc. | ▪ All membranous organelles are present |
| ▪ Cell wall is present | ▪ Cell wall is present only in plants |
| ▪ Ex: Bacteria & Archea | ▪ Ex: Animals & Plants |

P.S: Eukaryotic cell wasn't mention in the slides but it is written with the objectives.

# Cell envelope and external structure of bacteria:

- Cell wall: it is chemically structured of peptidoglycan.

Its function is: Rigidity, Protection, Shapes bacteria, Porous, Cell division, Antigenic determinants.

Some of the bacteria has no cell wall "mycoplasma". It is natural and stable. Some of its species are pathogenic.

- Cell membrane: Double layered structure composed of phospholipid and protein, it acts as semi permeable membrane and it is a site of numerous enzymes.
- Flagella: It is structured of basal body, hook and long filaments that are composed of Flagellin.

It is distributed to: Peritrichous, Monotrichous, Lophotrichous.

Its function is: Motility and Chemotaxis.

- Pilli: Short filaments that are composed of pilin.

It has two classes:

Common pili (responsible for adhesion & colonization) & Sex pili (responsible for conjugation)

- Capsule: Amorphous material surrounds bacteria.

Usually polysaccharide, occasionally protein.

Its function is: Inhibits phagocytosis & Acts as Virulence factor in some bacteria by assessing attachment to the surfaces.

# Internal structure of bacteria:

- Mesosomes: Convoluted invaginations of cytoplasmic membrane.

Involved in DNA segregation during cell division & respiratory activity [1]

Involved in chemotaxis & active transport of solutes.

- Core: Composed of: Cytoplasmic inclusions, Ribosomes & Nucleoid.

✓ Cytoplasmic inclusions: Nutritional storage granules. Ex: Volutin, lipid & Starch.

✓ Ribosomes: it is distributed throughout the cytoplasm, site of protein synthesis.

Composed of: RNA & Protein.

✓ Nucleoid: Circular single stranded chromosome.

- Spores: Small, dense, metabolically inactive, non- reproductive structures produced by Bacillus & Clostridium. It is often associated with the cell wall. Enables the bacteria to survive adverse environmental conditions. Contain high con. of Calcium dipicolonate. Resistant to heat[2],dissection & disinfectants.

It is described as: Terminal spores, Sub-terminal spores & Central spores.

Its preparation is used for checking the efficacy of autoclaves (أجهزة التعقيم)

Ex: B. subtilis & B. sterothermophilus.

[1]Mesosomes contain some enzymes that's why they are involved in respiratory activity.

[2]They resist heat over 100C.

# Two groups of cell wall depending on reaction to GRAM STAIN:

| Gram Positive Bacteria | Gram Negative Bacteria |
| --- | --- |
| Thick "multilayered" peptidoglycan | Thin "Single layered" peptidoglycan |
| Stain purple | Stain red |
| Teichoic acids[1] are present | Teichoic acids are absent |
| Flagella has 2 rings in basal body | Flagella has 4 rings in basal body |
| Exotoxins produced | Endotoxins produced (السم الداخلي) |
| Antigens: Either polysaccharide (Lancefield) or protein (Griffith) | Outer membrane: specific proteins, such as lipopolysaccharide |
| Conjugation involves clumping of cells and secretion of pheromones. | Conjugation mediated by plasmid called F factor (fertility) |
| Sex pili is absent | Sex pili is present |

[1] anchors cell wall to cell membrane, epithelial cell adhesion.

# Bacterial Genetics:

- Genetics is the study of inheritance and variation. Its information encoded in DNA.
- Function of genetic material: Replication of the genome & Expression of DNA to mRNA then to protein.
- Genetic material is important in division and synthesis of protein.
- Replication in bacteria is Semi conservative.
- Genotype: the complete set of genetic determinants of an organism. (الطراز الجيني)
- Phenotype: expression of specific genetic material under particular set of growth condition. (النمط الظاهري)
- Wild type: reference (parent) strain- active. (original bacteria)
- Mutant: progeny with mutation- inactive
- Types of bacterial DNA:

✓ Chromosome: Haploid, circular molecule of double strand DNA attached to cell membrane.

✓ Plasmid: Extra chromosomal DNA composed of double stranded DNA. Govern their own replication.

- Bacteria can live without plasmids. It only adds some functions to certain bacteria.
- Types of plasmid:

✓ R-Plasmids: genes code for antibiotic resistance in Gram negative bacteria.

✓ Col-Plasmids: in Enterobacteria, codes for extracellular toxins.

✓ F-Plasmids: transfer of chromosome at high frequency of recombination into recipient bacteria during mating. Ex: F- becomes F+.

# Genetic variation in bacteria:

- It takes place in: Mutation, Gene transfer.
- Mutation[1]: Inheritable changes in the structure of genes (DNA).

Result in gene defect could be alternation in:

Transcription, Amino acid sequence, Function Ex: Antibiotic resistance & Lethal.

- Inactive mutated form is a mutant allele Vs. active wild type allele.
- Types of mutation: Base substitution, Deletion, Insertion, Inversion, Duplication.
- Classification of mutations:

✓ Resistance mutation: affect structure of cell protein.

✓ Auxotrophic mutation: affect biosynthetic enzyme resulting in a nutritional requirement of mutant cell.

✓ Lethal mutation: it can kills the bacteria.

- Transposable Elements: Genetic units capable of mediating own transfer from chromosome to another, from location to other on same chromosome or between plasmid and chromosome or phage DNA,

by two types: 1. Transposons 2. Insertion sequence

[1]Mutation changes the features of the bacteria. That's how we know if there are bacteria or not.

- Gene transfer is three types:

✓ Transformation:

A fragment of exogenous naked bacterial DNA are taken up and absorbed into recipient cells.

VERY IMPORTANT !! ⟶ Ex: Haemophilus influenzae & Streptococcus pneumoniae.

✓Transduction:

Phage mediated transfer of genetic information from donor to recipient cells.

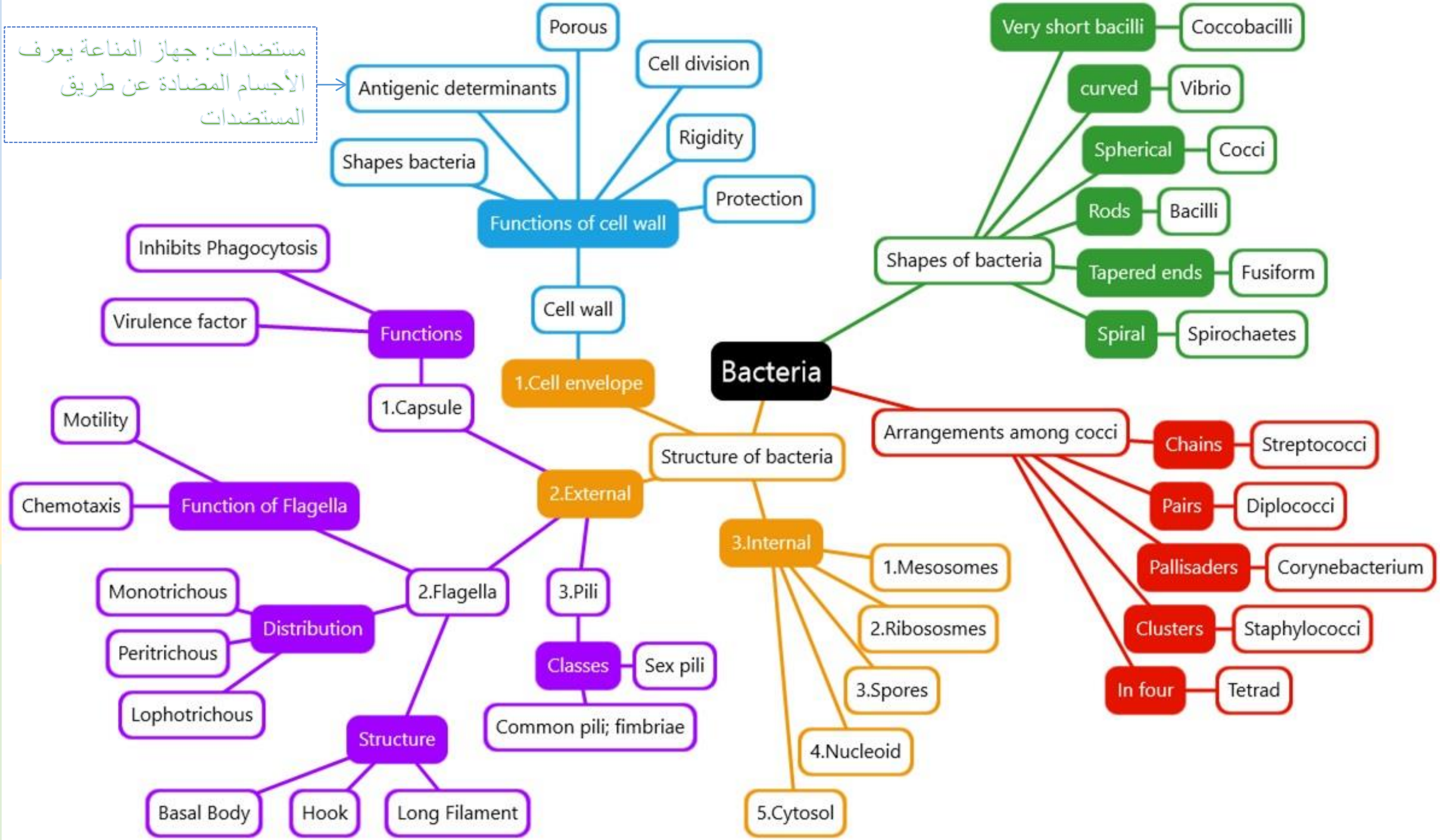
VERY IMPORTANT !! ⟶ Ex: Beta – lactamase production in S. aureus & Toxin production in Corynebacterium diphtheriae.

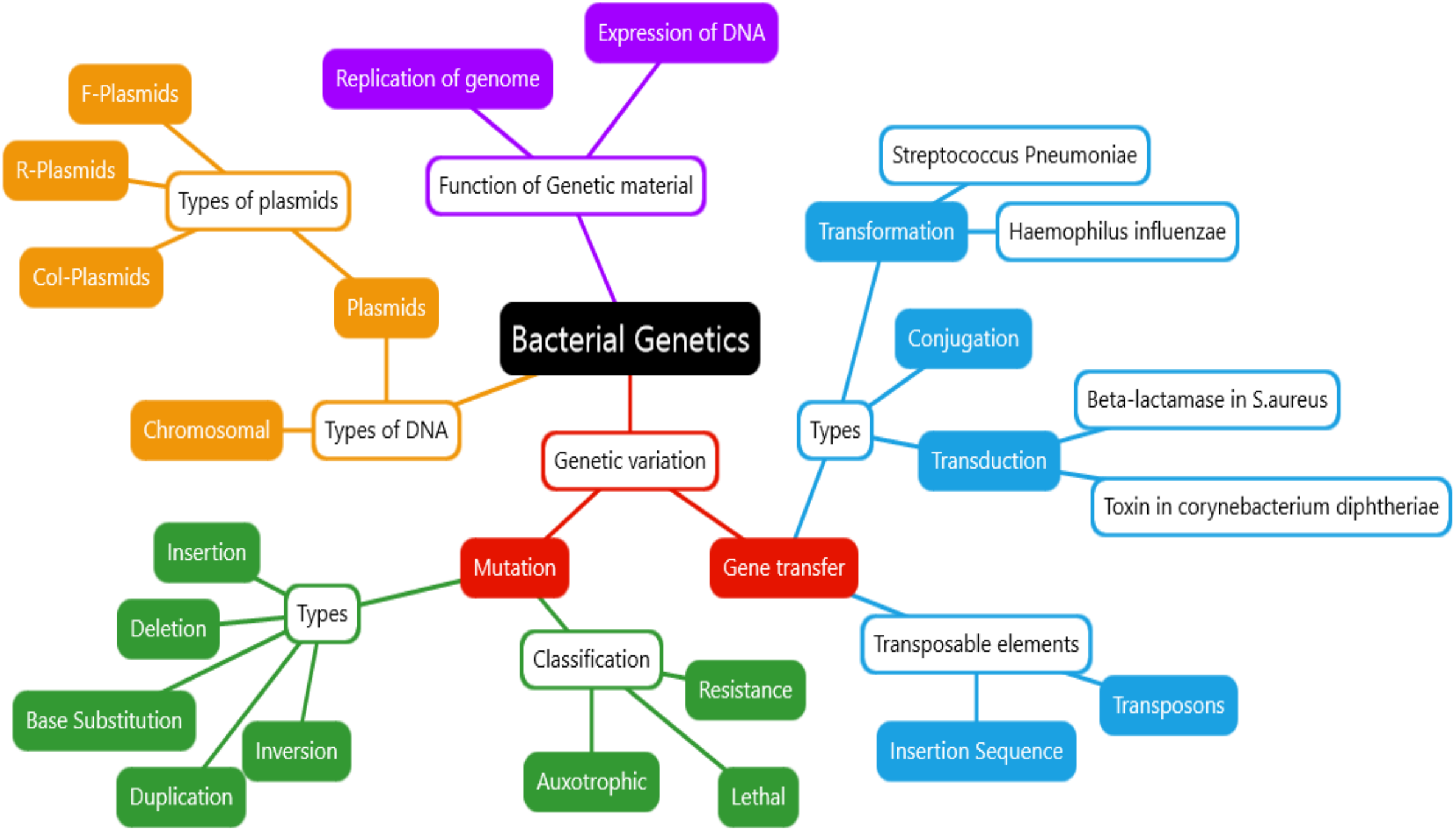
✓ Conjugation:

Cell contact required and genes reside on plasmid resident within donor (male) cells transfer to recipient (female) cell (mating).

- After gene transfer, there are three possible fates:

1. Exogenous DNA degraded by nuclease.
2. Stabilized by circulation, become plasmid.
3. Form a partially hybrid chromosome with segment derived from each source.


مستضدات: جهاز المناعة يعرف الأجسام المضادة عن طريق المستضدات
Bacteria
Shapes of bacteria
Very short bacilli
Coccobacilli
curved
Vibrio
Spherical
Cocci
Rods
Bacilli
Tapered ends
Fusiform
Spiral
Spirochaetes
Arrangements among cocci
Chains
Streptococci
Pairs
Diplococci
Pallisaders
Corynebacterium
Clusters
Staphylococci
In four
Tetrad
Structure of bacteria
1.Cell envelope
Cell wall
Functions of cell wall
Porous
Antigenic determinants
Cell division
Rigidity
Shapes bacteria
Protection
Functions
Inhibits Phagocytosis
Virulence factor
1.Capsule
2.External
2.Flagella
Function of Flagella
Motility
Chemotaxis
Distribution
Monotrichous
Peritrichous
Lophotrichous
Structure
Basal Body
Hook
Long Filament
3.Pili
Classes
Sex pili
Common pili; fimbriae
3.Internal
1.Mesosomes
2.Ribososmes
3.Spores
4.Nucleoid
5.Cytosol


Bacterial Genetics
Function of Genetic material
Expression of DNA
Replication of genome
Types of DNA
Plasmids
Types of plasmids
F-Plasmids
R-Plasmids
Col-Plasmids
Chromosomal
Genetic variation
Mutation
Types
Insertion
Deletion
Base Substitution
Inversion
Duplication
Classification
Resistance
Auxotrophic
Lethal
Gene transfer
Types
Transformation
Streptococcus Pneumoniae
Haemophilus influenzae
Conjugation
Transduction
Beta-lactamase in S.aureus
Toxin in corynebacterium diphtheriae
Transposable elements
Transposons
Insertion Sequence

# Quiz

1.Spherical shaped bacteria are called:

a) Bacilli b)Vibrio c)Cocci

2.Fine short filament extruding from cytoplasmic membrane:

a) Flagella b) Pili c) Cilia

3.Sex pilli are responsible for:

a) Conjugation b) Motility c) Digestion

4.Cytoplasmic membrane of bacteria act as ..... membrane:

a) Permeable b) Selective c) Semi permeable

5.Which of the following is involved in DNA segregation and respiratory activity?

a) Mesosomes b) Ribosomes c) Spores

ANSWERS: 1.C 2.B 3.A 4.C 5.A

# Quiz

6.The site of protein synthesis:

a) Ribosomes b) Cell membrane c) Pili

7..... enables the bacteria to survive adverse environmental conditions:

a) Spores b) Nucleoid c) Cytoplasmic inclusion

8.The complete set of genetic determinants of an organism is its:

a) Wild type b) Genotype c) Phenotype

9.Inactive mutated form is a wild type allele.

a) T b)F

10.Transformation:A fragment of exogenous naked bacterial DNA are taken up and absorbed into recipient cell. a) T b)F

ANSWERS: 6.A 7.A 8.B 9.B 10.A