MED437
KING SAUD UNIVERSITY

MICROBIOLOGY
437

Microbiology – Lecture 1
Bacterial structure , Functions & Genetics

TEAM 437

Red: important
Green : doctor notes
Black : original slides
Grey: extra information

Objectives

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1. Define the cellular organization of bacteria and know the differences between Eukaryotes and Prokaryotes.
2. Know major structures of bacteria and its function.
3. Know the structure of cell wall of bacteria including the differences between Gram positive and Gram negative bacteria and main functions.
4. Know the external structures of bacteria with and functions .
5. Know the cytosol and internal structures of bacteria .
6. Describe bacterial spores and its application in the practice of medicine.
7. Know basic information about bacterial genetics and replication of bacteria .
8. Describe plasmids , its origin , types and its importance in clinical practice.
9. Recalls genetics variations, including ; mutation and mechanisms of gene transfer and its implication on bacterial resistance to antimicrobial agents.

The Difference Between Prokaryotes and Eukaryotes

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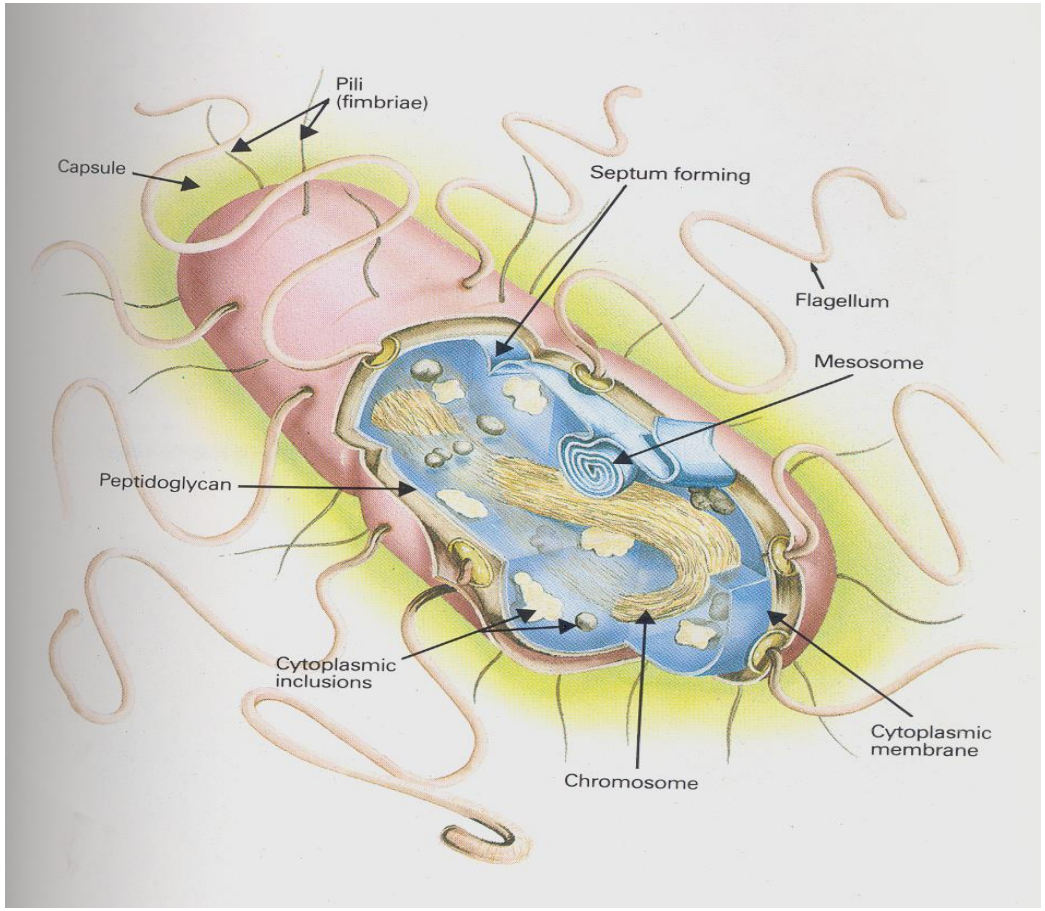

Prokaryotes	Eukaryotes
No nucleus	Nucleus
Unicellular organisms	Multicellular organism
divide by binary fission	Undergo mitosis
No organelles	Membrane-bound organelles
Small	Ten times the size of prokaryotic cells.

Similarities
They both have DNA as their genetic material.
They are both membrane bound
They both have ribosome

Bacteria:

Is a heterogeneous group of unicellular organisms , about 1-8 µm in diameter

- Bacteria is a Prokaryote (has a primitive nucleus):
- One chromosome
- No nuclear membrane
- No mitochondria
- No sterols
- Bacteria contain Plasmids: an extra piece of DNA.

Shapes:

- Spherical / Oval , e.g. Cocci
- Rods , e.g. Bacilli
- Very short Bacilli , e.g. Coccobacilli
- Tapered end , e.g. Fusiform
- Club-shaped / Curved , e.g. Vibrio
- Helical / Spiral , e.g. Spirochetes

For more information click here!

Arrangements of Bacteria:

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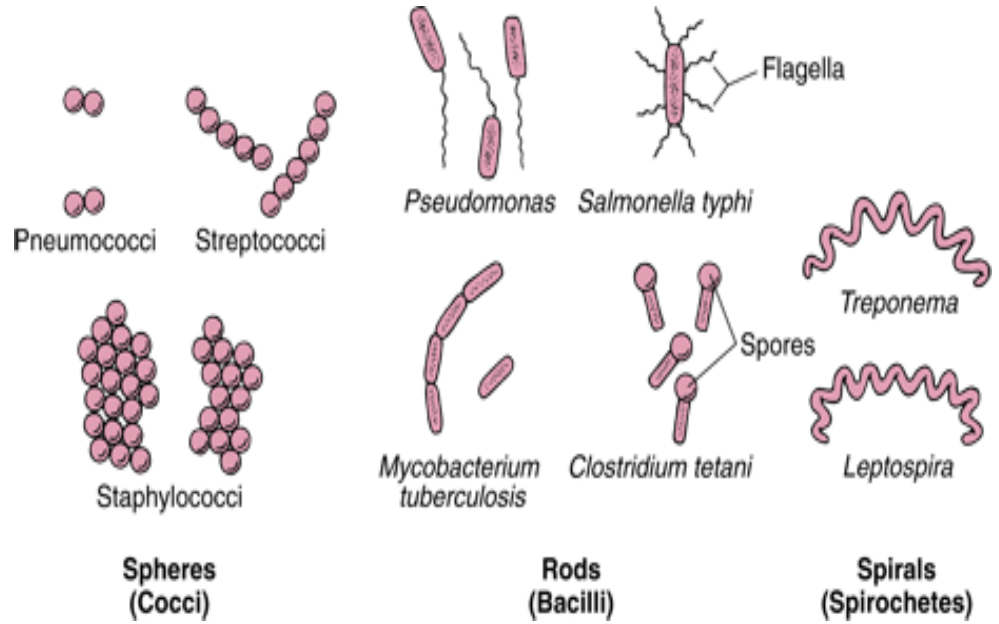
Arrangements among Cocci:

Pairs	Diplococci
Chains	Streptococci
Clusters	Staphylococci
In four	Tetrad
Palisades	Corynebacterium



Major Bacterial Structure: Cell Wall

There is a difference between “cell wall” and “cytoplasmic membrane” !! Cytoplasmic membrane in pro –eukaryotes , while cell wall in prokaryotes and plants and some kind of animals

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Definition:

It’s rigid, surrounds the cytoplasmic membrane and internal structures.

Function :

- Rigidity
- Protection
- Shapes bacteria
- Cell division
- Porous: permeable to low molecular weight molecules
- Antigenic determinants

Note from doctor: Mycoplasma naturally has no cell wall

Two groups of bacteria depending on reaction to GRAM STAIN!

Gram positive bacteria: stain **blue/purple** by Gram stain. 	Gram negative bacteria: stain **red** by Gram stain 
• Thick peptidoglycan. • Closely associated with cytoplasmic membrane. • Teichoic acid : anchors cell wall to cell membrane epithelial cell adhesion. • Antigens: - polysaccharides (Lancefield) -protein (Griffith)	• Thin peptidoglycan • Outer membrane that contains: 1- Specific proteins (porins) important in the transport of hydrophilic molecules 2- Lipopolysaccharide & lipid (ENDOTOXIN)

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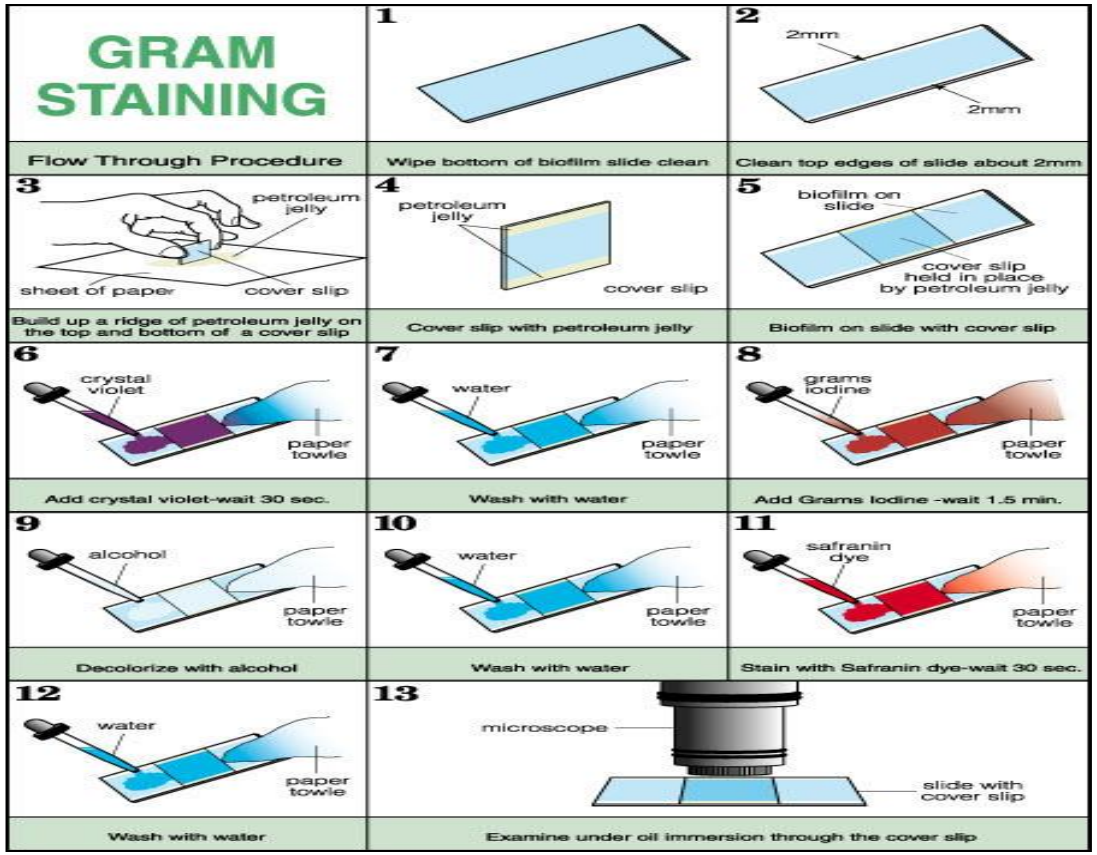
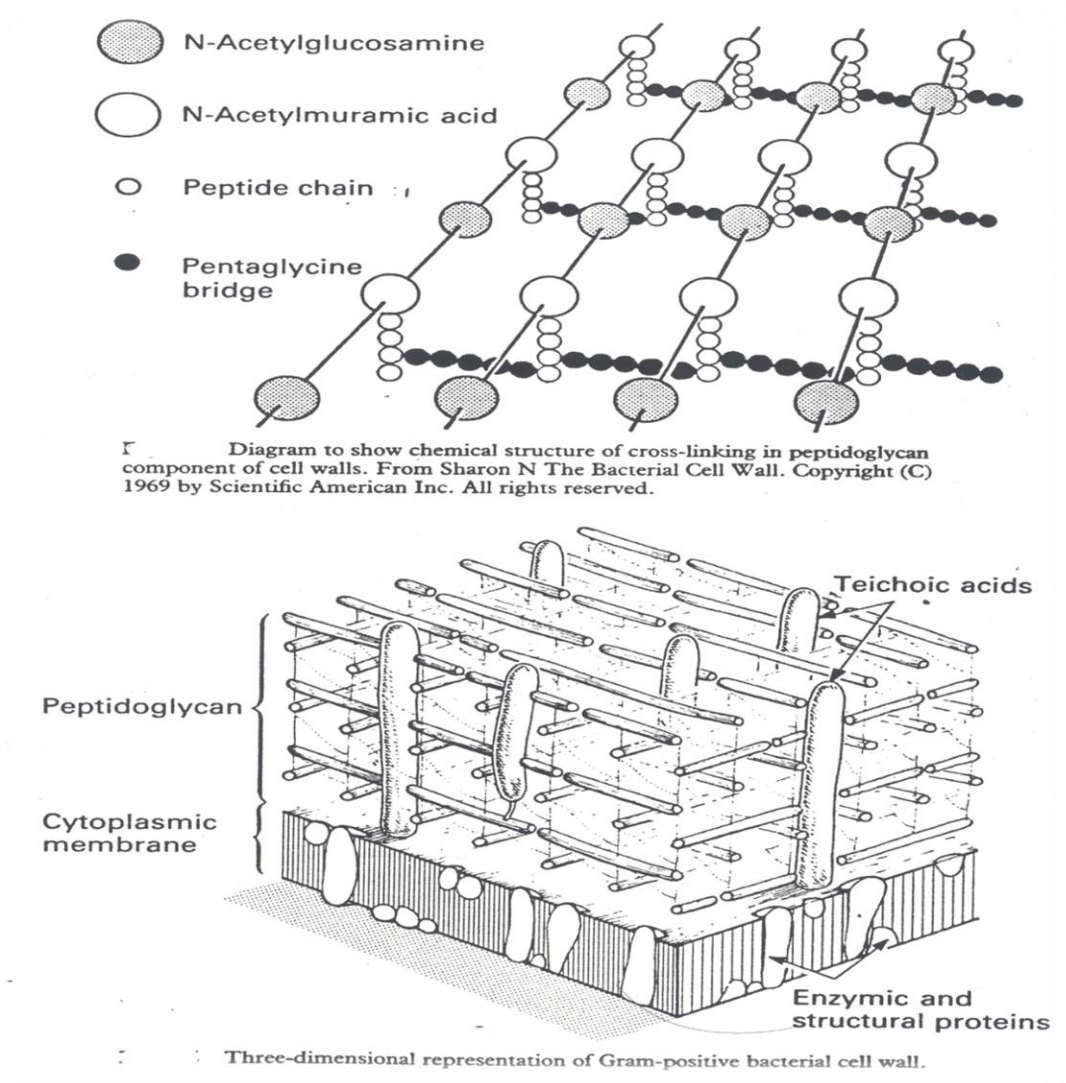
What is Peptidoglycan?

Chemical structure of bacterial cell wall is **peptidoglycan** the rigid part is **mucopeptide** composed of alternating strands of **N- acetyl muramic acid** and **N- acetyle glucosamine** linked with **peptide sub units**.





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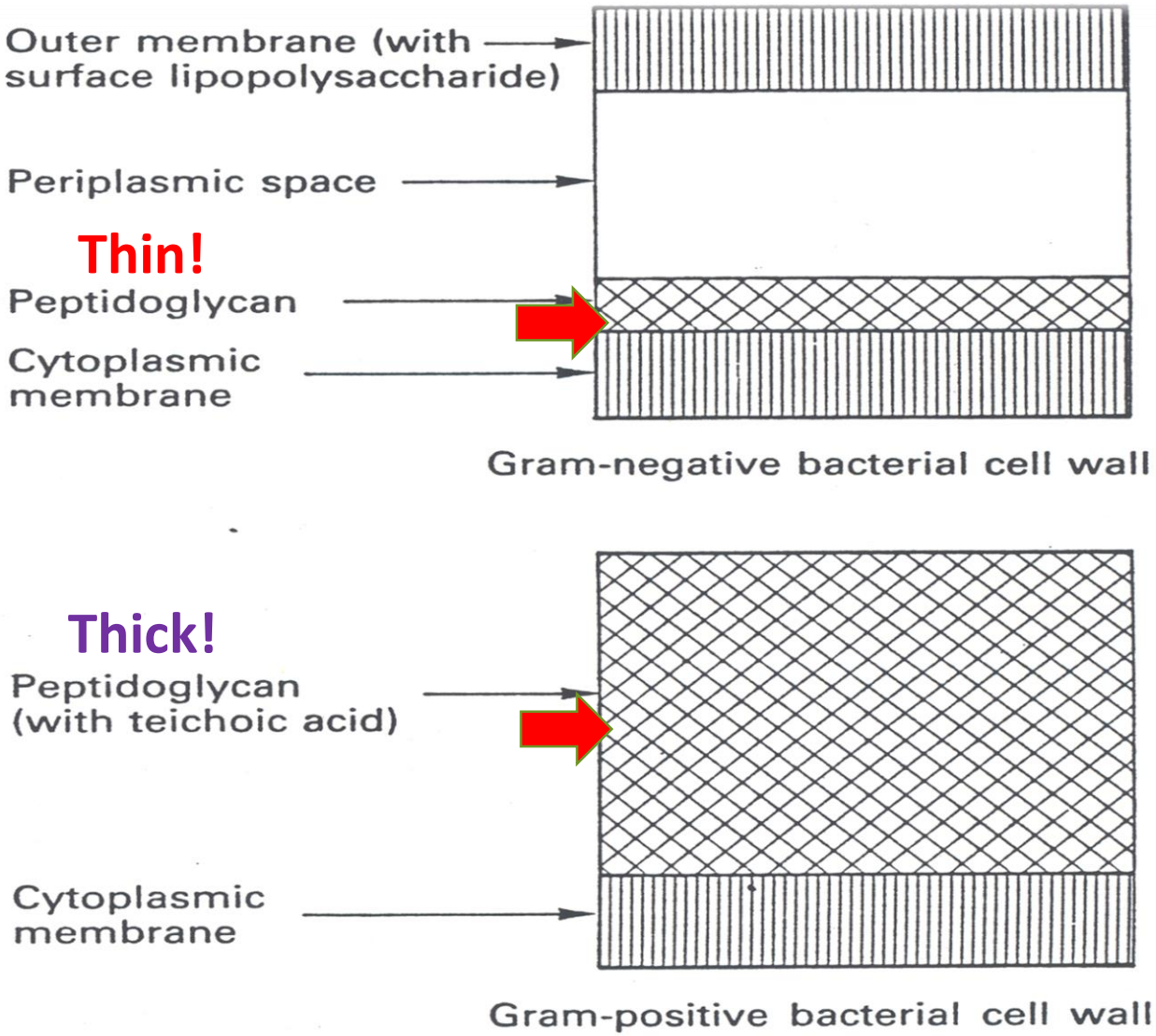
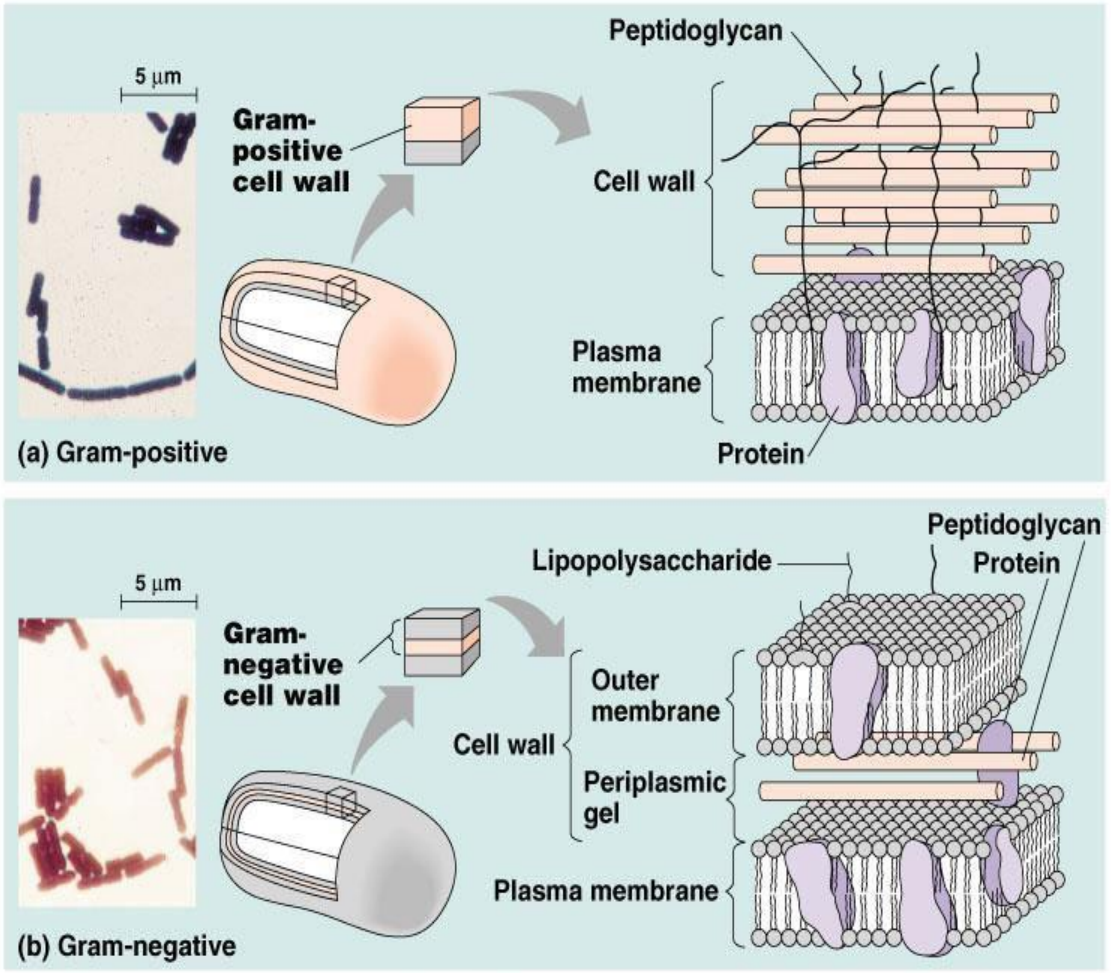


Diagram showing the structure of Gram-negative and Gram-positive bacterial cell walls.



External Structures of Bacteria

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External protrude from the cell into the environment:

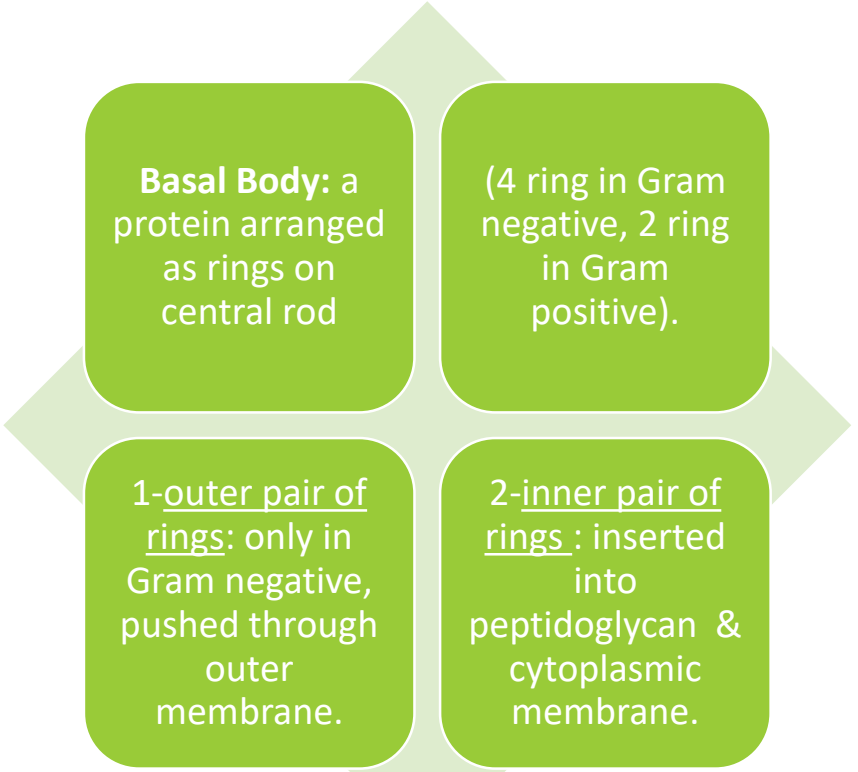
- Flagella
- Pili
- Capsule

Flagella:

Helical filaments
Composed of protein FLAGELLIN.
Found **in Gram positive & Gram negative** bacteria.
Distribution:
- Peritrichous
- Monotrichous
- Lophotrichous

Chemotaxis is the movement of an organism in response to chemical stimuli

Structure of flagella:

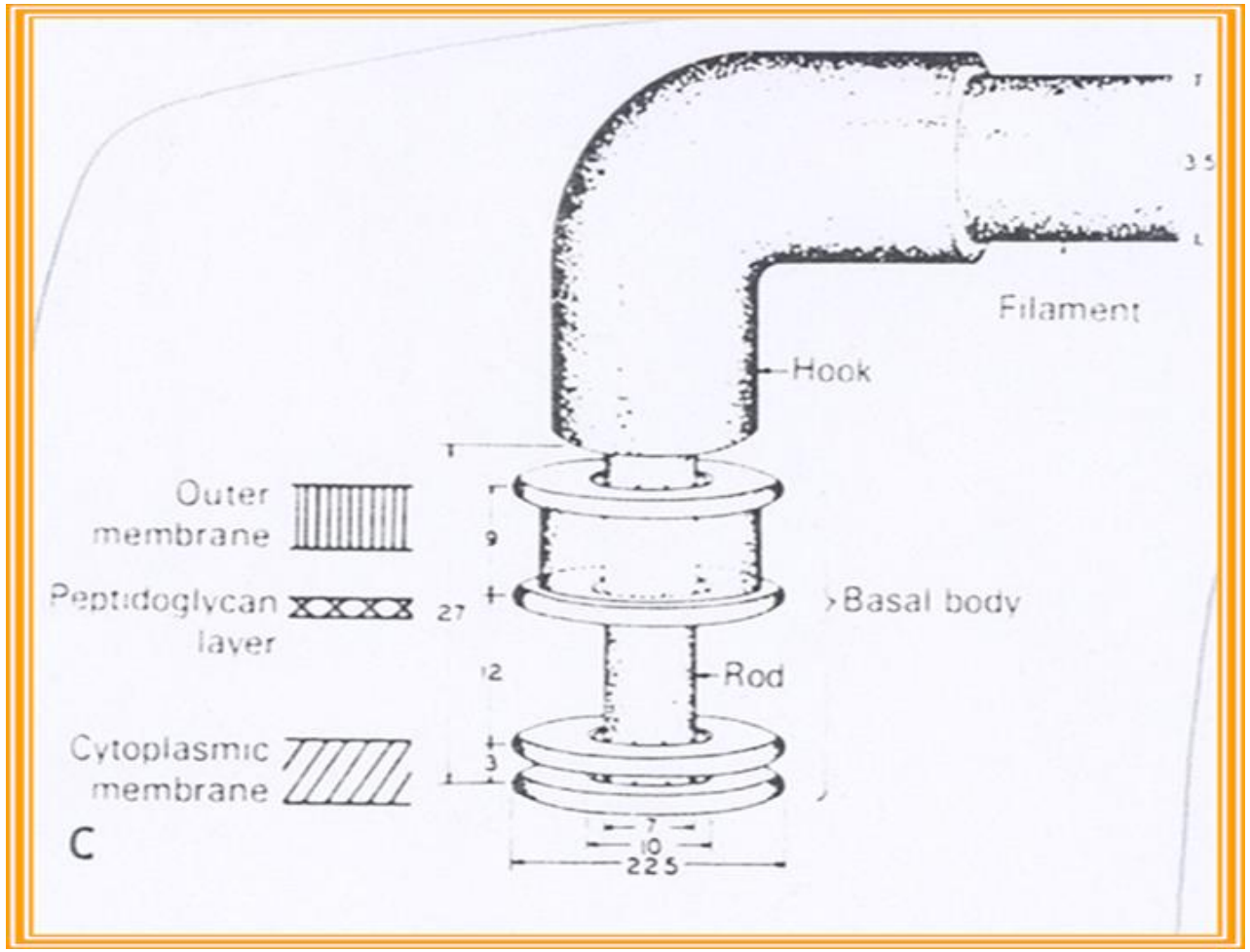


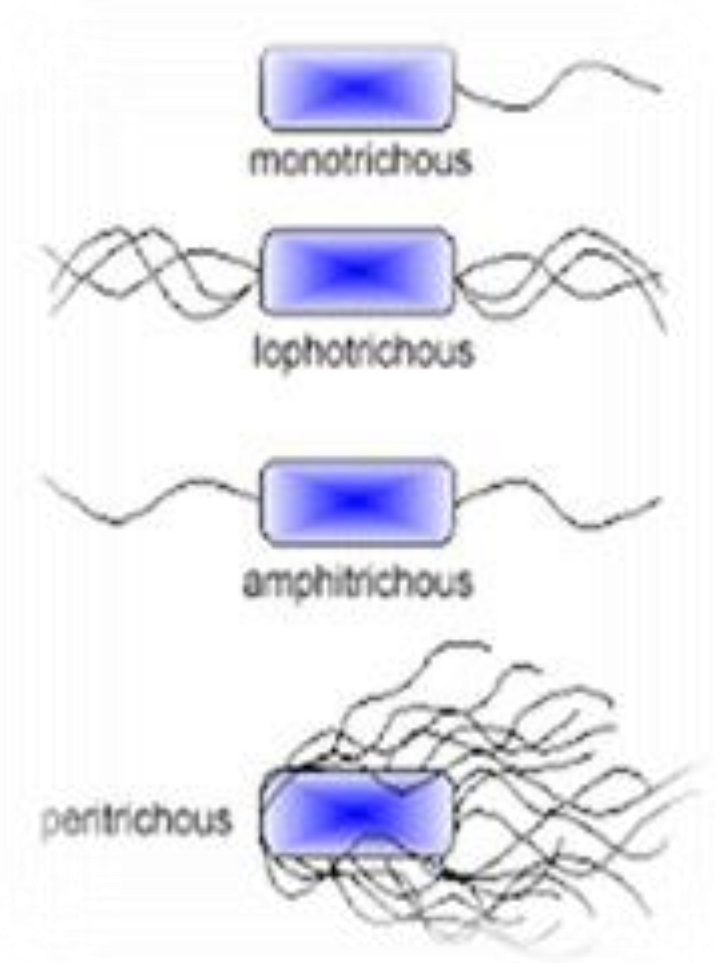
Hook: a bent structure , acts as a joint

Long Filament: a flagellin protein

Function of Flagella: motility & chemotaxis

Structure of Flagella:





External Structures of Bacteria

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Pili

- Fine short filaments extruding from cytoplasmic membrane.
- Found on the surface of many Gram negative & Gram positive bacteria.
- **Composed of protein Pilin.**
- **Two classes:**

1. **Common pili** (*fimbriae*): covers the surface— responsible for: adhesion & colonization
2. **Sex pili** : in some bacteria only, responsible for conjugation.

NOTE : GENE SHARING IS SEX PILI

Capsule

- Amorphous material surrounds bacteria.
- Usually polysaccharide.
- Occasionally protein.
- Function:
  1. Inhibits phagocytosis.
  2. Acts as Virulence factor in some bacteria by assessing attachment to the surfaces.

Cytoplasmic Membrane

Cytoplasmic membrane (cell membrane)

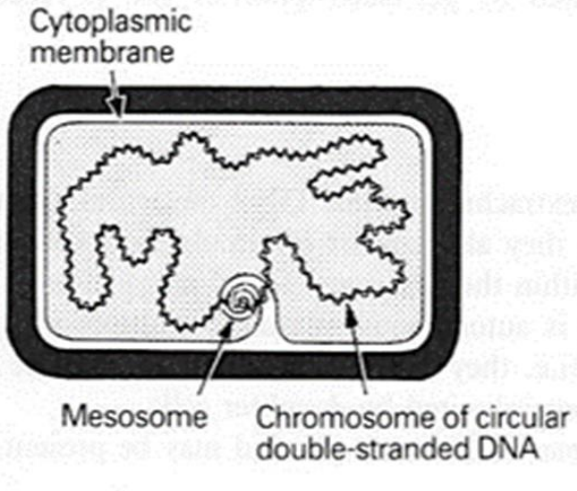
- Double layered structure composed of phospholipid & protein.
- Act as semi- permeable membrane (passive diffusion).
- Site of numerous enzymes involved in active transport of nutrients and various metabolic processes.

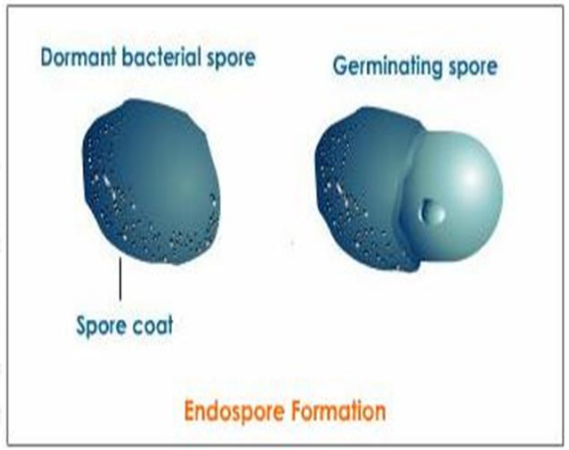
Internal Structures of Bacteria

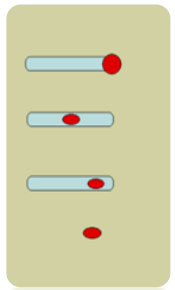
Mesosomes : convoluted invaginations of cytoplasmic membrane.

Function:

- Involved in DNA segregation during cell division & respiratory activity.
- Contain receptors involved in chemotaxis.
- Permeability barrier (active transport of solutes).







Spores of Bacteria

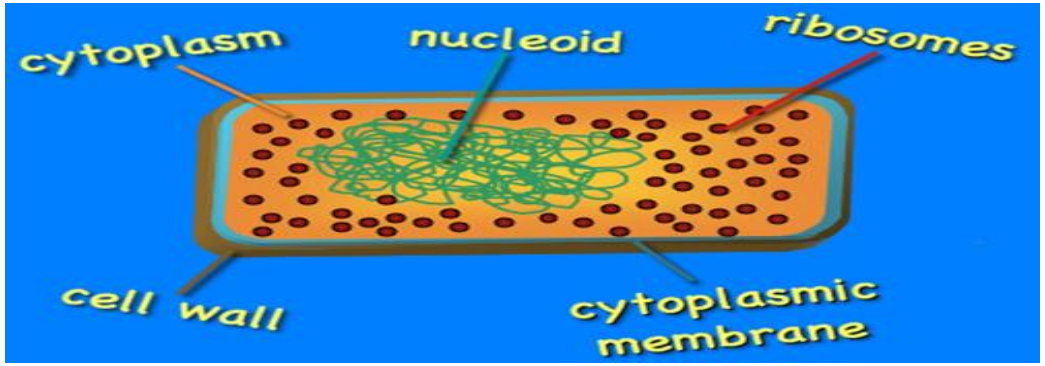
- Small, dense, metabolically inactive, non- reproductive structures produced by Bacillus & Clostridium.
- Enables the bacteria to survive adverse environmental conditions.
- Contain high concentration of Calcium dipicolonate.
- Resistant to heat, dissecation & disinfectants.
- Often remain associated with the cell wall.

Spores are described as:

- Terminal spores
- Sub-terminal spores
- Central spores

Spores germinate when growth conditions become favorable to produce vegetative cells.

Application in medical practice :spore preparations used for checking the efficacy of Autoclaves, eg. Bacillus subtilis & Bacillus sterothermophilus.



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<u>The core of bacteria is composed of :</u>

1. Cytoplasmic inclusions
2. Nucleoid (nuclear body)
3. Ribosomes

1- **Cytoplasmic inclusions:**

Are nutritional storage granules , examples:

- volutin
- Lipid
- Starch / or Glycogen

2- **Nucleoid (Nuclear Body)**

Circular single stranded chromosome (bacteria genome or DNA)

No nuclear membrane

DNA undergoes semi-conservative replication , bidirectional from a fixed point

3-**Ribosomes of Bacteria:**

- ✓ Distributed throughout the cytoplasm
- ✓ Site of protein synthesis
- ✓ Composed of RNA and protein

Note:
البكتيريا تقدر تعيش بدون بلازميد، فهو يعطي البكتيريا صفات كمالية غير أساسية.

Bacterial Genetics:

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It is the study of inheritance and variation. And the

genetic information is encoded in DNA.

Function of genetic material:

1- Replication of the genome

2- Expression of DNA to mRNA then to protein.

Genotype: the complete set of genetic determinants of an organism.

Phenotype: expression of specific genetic material .

Wild type: reference (parent) strain

Mutant: progeny with mutation.

Types of DNA in bacteria

Plasmids – extra chromosomal

1. Extra chromosomal DNA composed of double stranded-DNA.
2. Found in most species of bacteria. (especially Gram negative bacteria)
3. Unknown orgin
4. Govern their own replication

Application :Genetic exchange, amplify genes

*تستخدم في الهندسة الوراثية

Transfer by conjugation.

Contains 3 types:

Col-plasmids: in Enterobacteria, codes for extracellular toxins. (تقتل بكتيريا أخرى)

F-plasmids: (fertility) factor, transfer of chromosome during mating .

R-plasmids: genes code for antibiotic resistance particularly Gram negative bacteria. (بكتيريا تكتسب مقاومة لمضادات حيوية من بكتيريا غيرها)

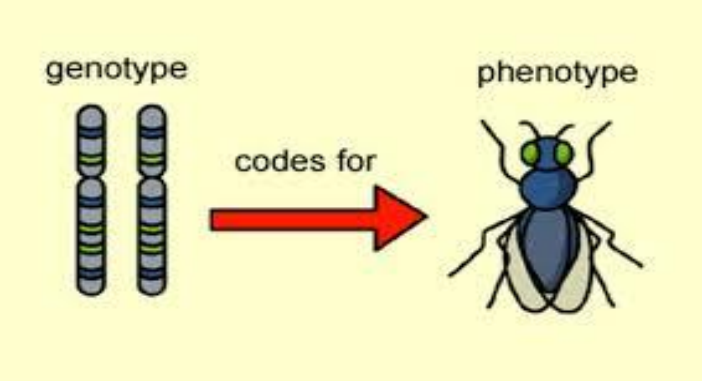
Chromosomal

1. Haploid (1n), circular molecule of double stranded- DNA attached to cell membrane. No nuclear membrane .
2. DNA a double helical structure, genetic code in Purine and Pyrimidine bases of nucleotides that makes DNA strand.
3. 3 bases comprise one code (codon), each triplet codon codes for one amino acid.

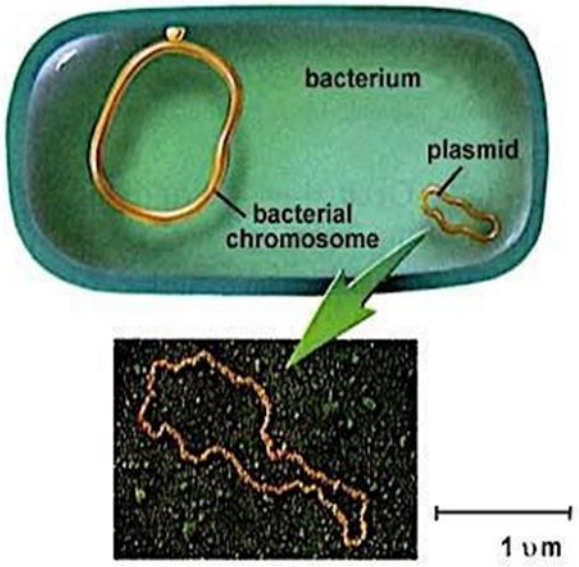
Replication is by binary fission.

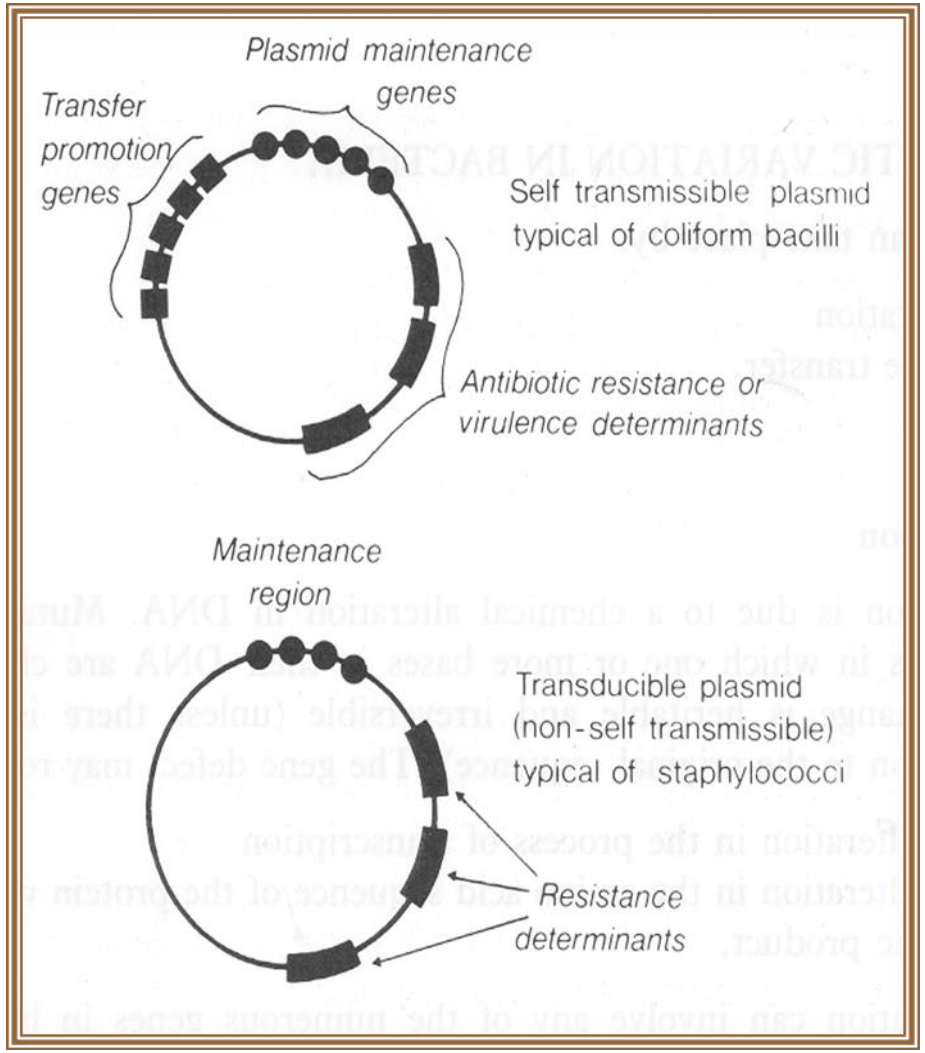
Notes:
Genotype: The genetic constitution (genome) النمط الجيني

Phenotype: Expressed features النمط الظاهري



Plasmids


bacterium
plasmid
bacterial chromosome
1 µm


Plasmid maintenance genes
Transfer promotion genes
Self transmissible plasmid typical of coliform bacilli
Antibiotic resistance or virulence determinants
Maintenance region
Transducible plasmid (non-self transmissible) typical of staphylococci
Resistance determinants

Genetic variation in bacteria -1- Mutation

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Mutation

- Inheritable changes in the structure of genes (DNA).
- Chemical changes in one or more bases of DNA.

(so their characteristics change)

Mutation /gene defect leads to alteration in:

- Transcription
- Amino acid sequences
- Function eg. Bacteria resistant to antibiotic.

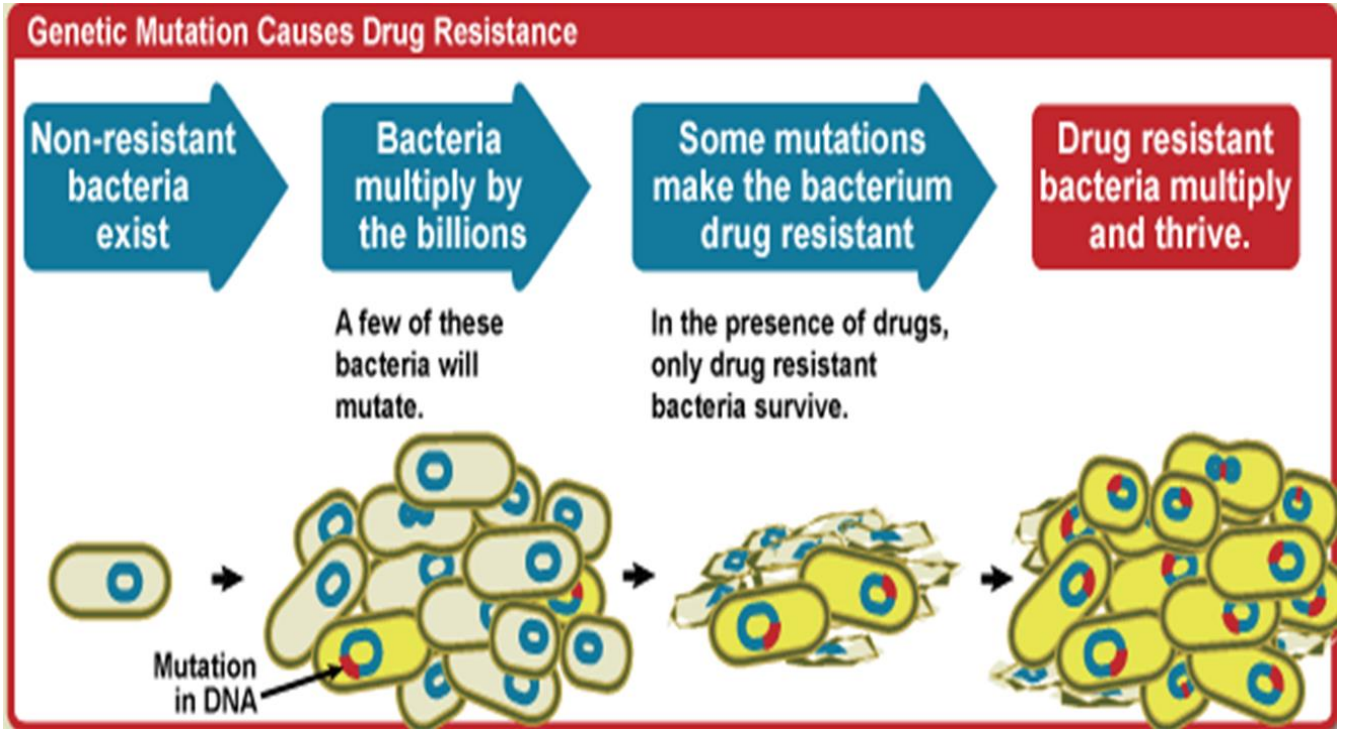
Depends on biological sequencing:

1- Resistance mutation: affect structure of cell protein. Main application in medical practice bacteria become resistant to antibiotics.

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

3- Lethal mutation: leads to death of bacteria.

Mutation Causes Antimicrobial Resistance



Genetic variation in bacteria -2- Gene transfer

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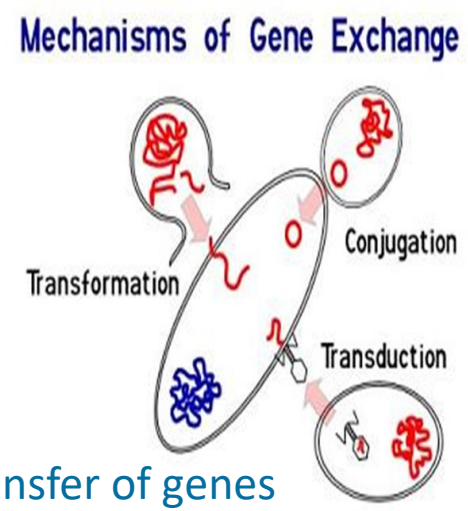
Gene Transfer Among Bacteria

Three mechanisms:

1- Transformation

2- Transduction

3- Conjugation.



Conjugation is the common way of transfer of genes resistant to antibiotics among bacteria in hospitals.

1- Major way bacteria acquire additional genes. (mainly gram negative bacteria)

2- **plasmid mediated (F factor -fertility)**
cell contact required and genes reside in plasmid within donor cells transfer to recipient cell (mating).

3- Gene encode changes in surface by producing a sex pilus .this facilitates capture of F- cells and the formation of a conjugation bridge through which ***DNA passes from F + into F-cells.***

Transformation

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

Common in *Haemophilus influenzae & Streptococcus pneumoniae* (they are very pathogenic especially in children). Bacteria become resistant to Ampicillin.

Transduction

Phage (a virus that infects/attacks bacteria) mediated transfer of genetic information from donor to recipient cells.

Example:

Beta – Lactamase production in *Staphylococcus aureus* :

Bacteria becomes resistant to penicillin.

Toxin production by *Corynebacterium diphtheriae.* (it gets the genes needed for the production of the toxin from the phage)

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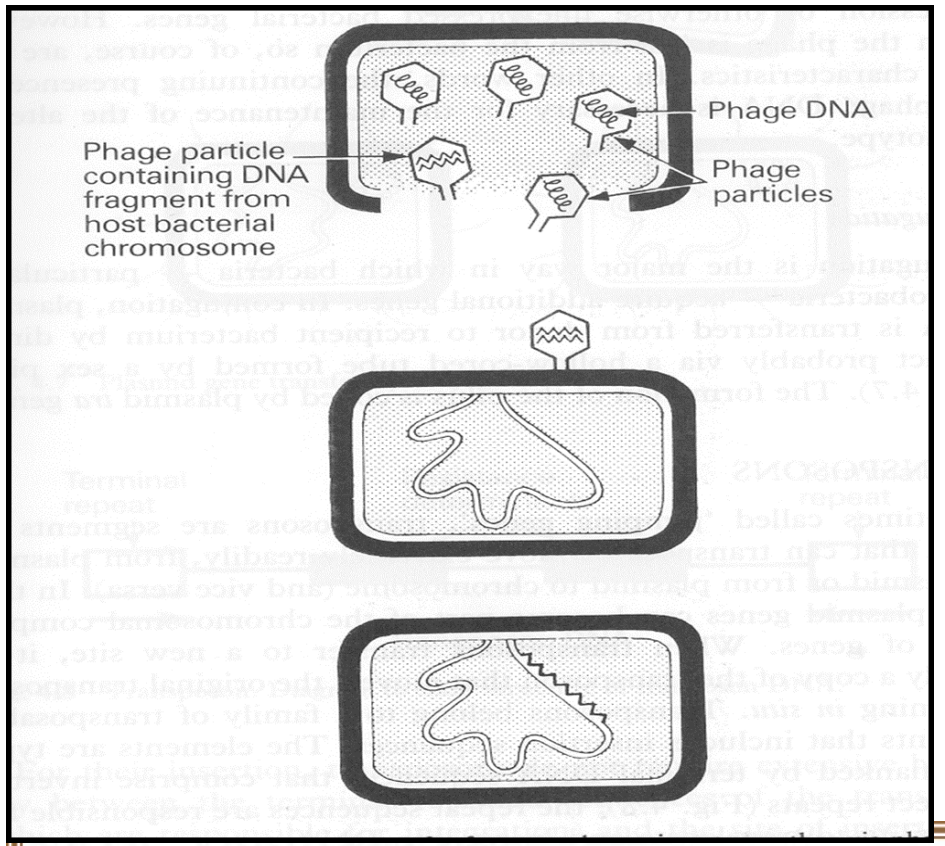
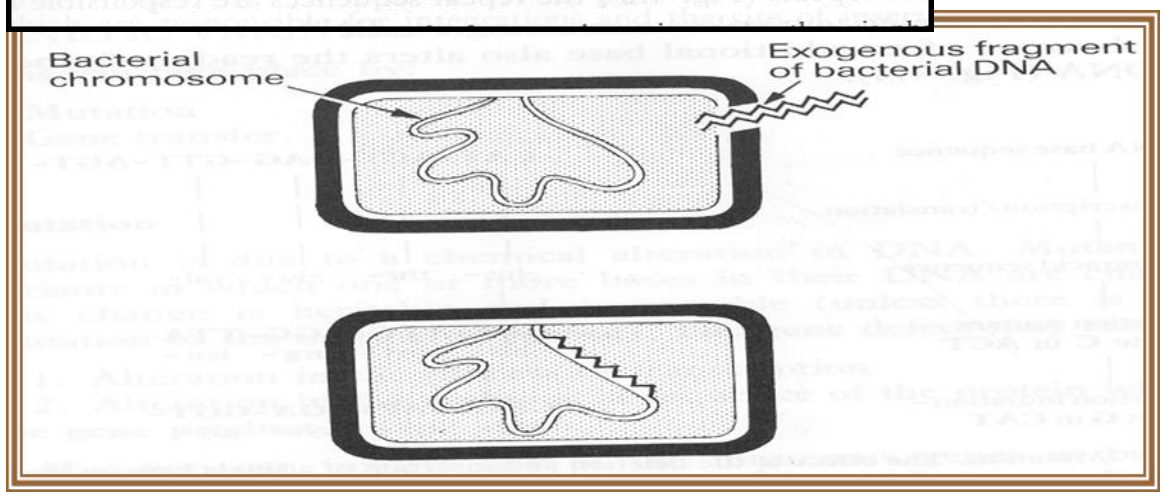
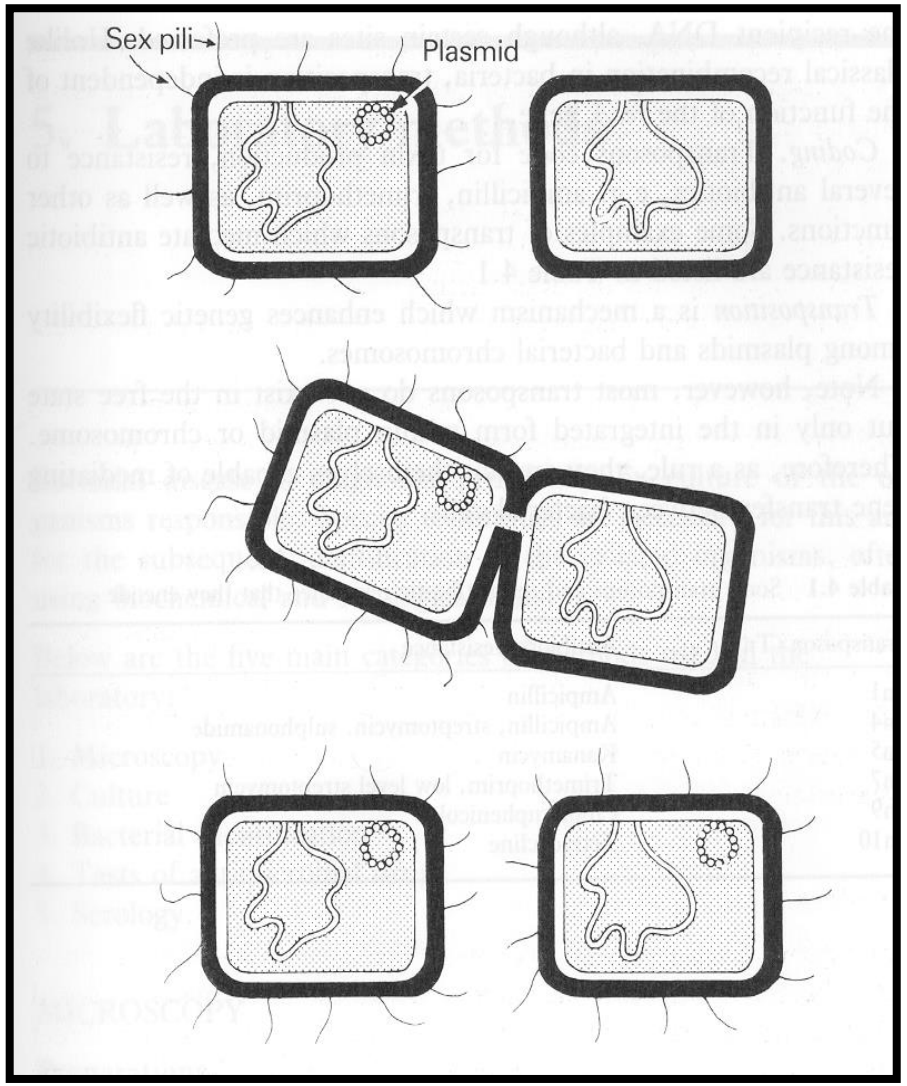
Transduction



Transformation



Conjugation



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Genetic Recombination

After gene transfer, there are three possible fates:

1-Exogenous DNA degraded by nuclease.

2-Stabilized by circulization and become plasmid.

3- Form a partially hybrid chromosome (كروموسوم مهجن) with segment derived from each source.

Transposable Elements

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

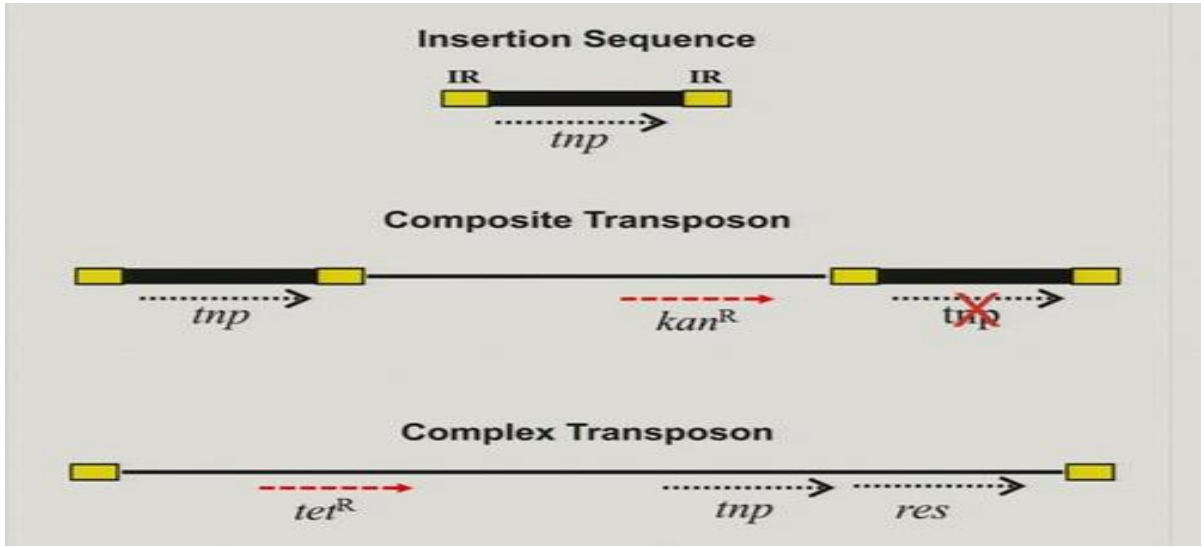
Types:

1- Transposons

2- Insertion sequence

NOTE

Transposable elements (TEs), also known as "jumping genes" or **transposons**, are sequences of DNA that move (or jump) from one location in the genome to another. Maize geneticist Barbara McClintock discovered TEs in the 1940s, and for decades thereafter, most scientists dismissed**transposons** as useless or "junk" DNA.



Quiz and references

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***Sherries* Medical Microbiology, an Introduction to Infectious Diseases.**

Latest edition, Kenneth Ryan and George Ray. Publisher : McGraw Hill .

bacteria genetics explained skip to 4:15

https://www.onlinequizcreator.com/bacterial-structure-functions-genetics/quiz-312607

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