Version 2

Bacterial structure and genetics

-Important -Extra -Notes

-In boy's slides -In girl's slides

MICROBIOLOGY TEAM 438

Objectives:

لا يوجد اختلاف بين سلايدات الطلاب والطالبات في هذه المحاضرة**

- ★ Define the cellular organization of bacteria and recall the differences between Eukaryotes and Prokaryotes.
- ★ Recall major structures of bacteria and its function.
- ★ Describe the structure of cell wall of bacteria including the differences between Gram positive and Gram negative bacteria and main functions.
- ★ Describe the external and internal structures of bacteria and their functions.
- ★ Describe bacterial spores and its application in the practice of medicine.
- ★ Recall basic information about bacterial genetics and replication of bacteria .
- ★ Describe plasmids , its origin , types and its importance in clinical practice.
- ★ Recall genetics variations, including ; mutation and mechanisms of gene transfer and its implication on bacterial resistance to antimicrobial agents.

Definition

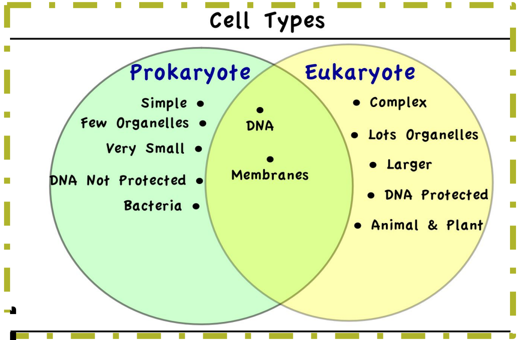
Diverse

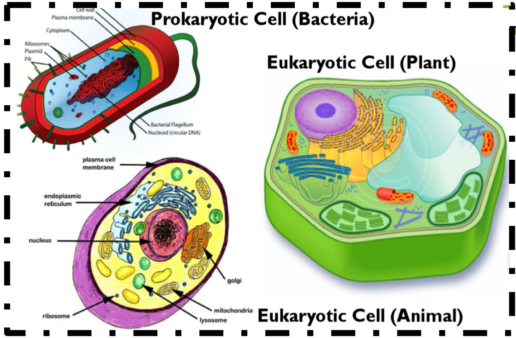
Bacteria : **Is a** **heterogenous** group of unicellular organisms , about 1-8 µm in diameter

Bacteria is a Prokaryote (has a primitive nucleus):

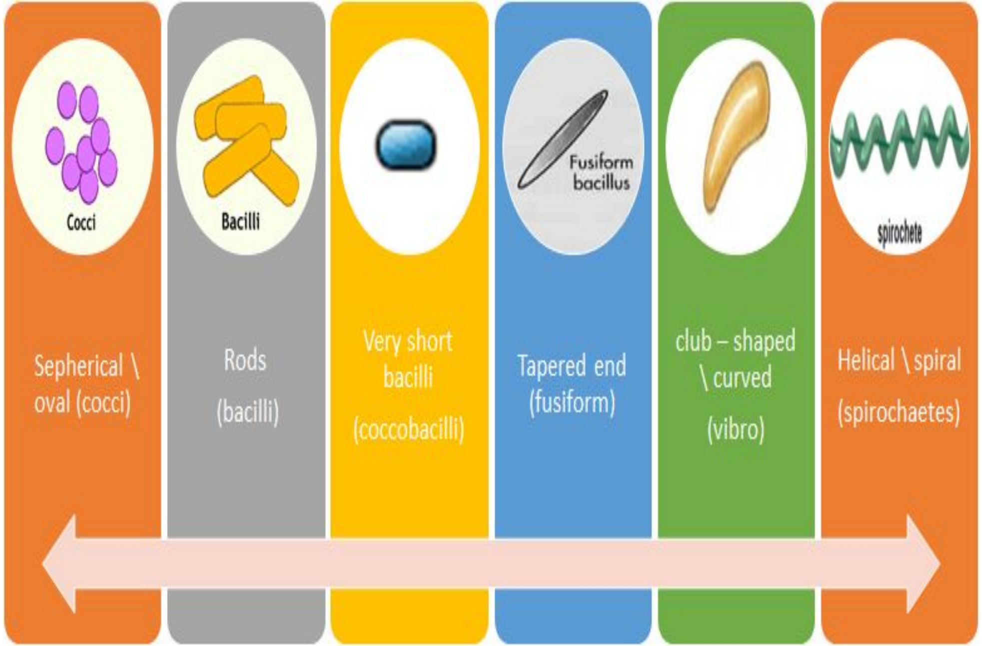
- one chromosome
- no nuclear membrane
- no mitochondria
- no sterols

Bacteria contain Plasmids: an extra piece of **DNA.**





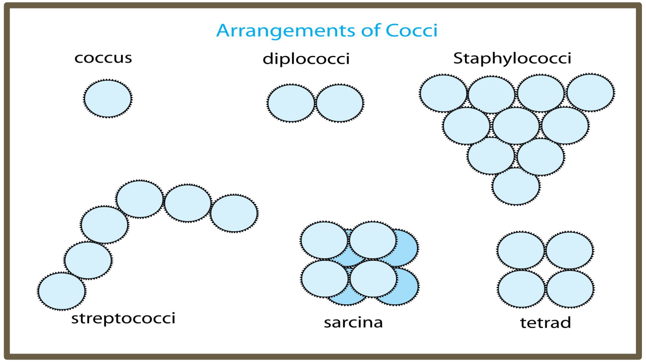
Shapes & Types of Bacteria



Arrangements of Bacteria

Arrangements among Cocci:

- Pairs (Diplococci)
- Chains (Streptococci)
- Clusters (Staphylococci)
- In four (Tetrad)
- Palisades (*Corynebacterium)*



Cell Wall of Bacteria

- ★ Bacteria are cells with rigid cell wall surround cytoplasmic membrane and internal structures.

Functions of cell wall:

- ★ Rigidity.
- ★ Protection.
- ★ Gives the shapes of bacteria.
- ★ Cell division.
- ★ Porous / permeable to low molecular weight molecules.
- ★ Antigenic determinants.

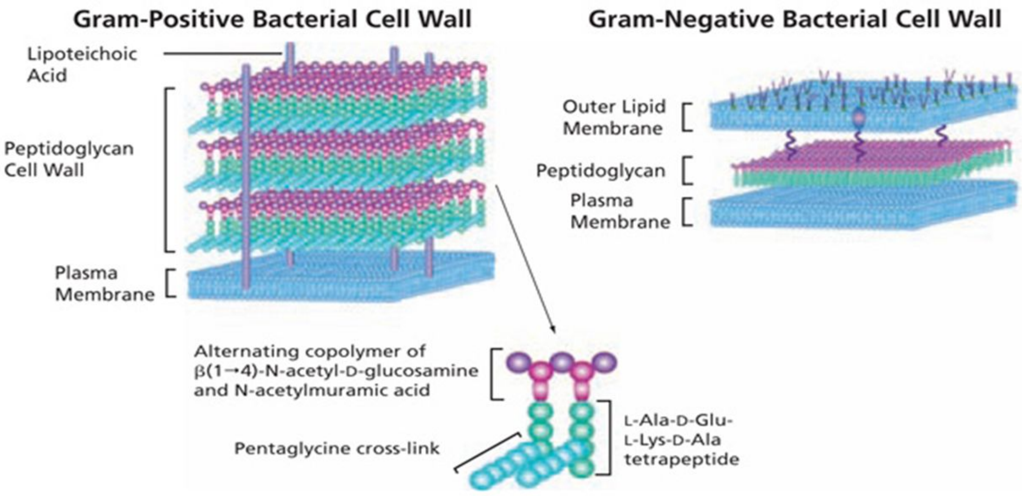
Polystructure composed of polysaccharide and protein function in identification (immune system)

Chemical structure of bacterial cell wall:

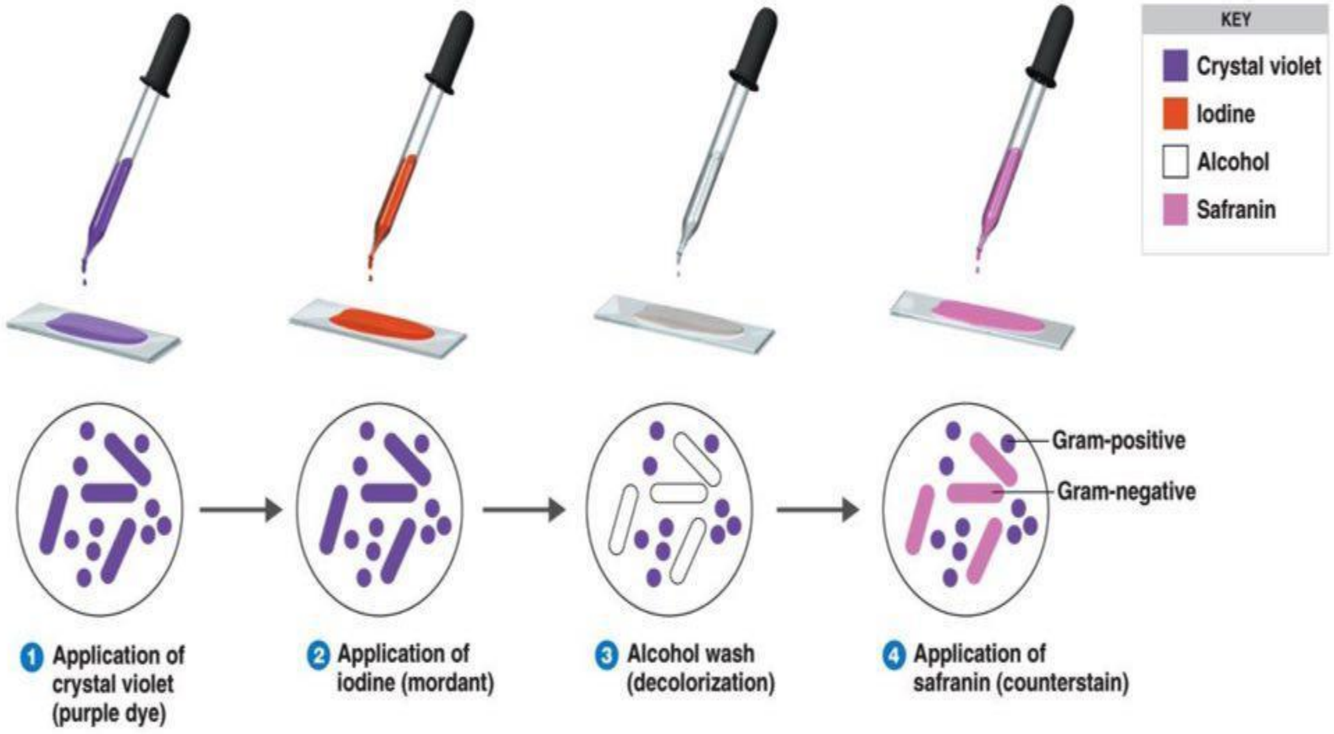
Peptidoglycan : " very imp chemical structure"

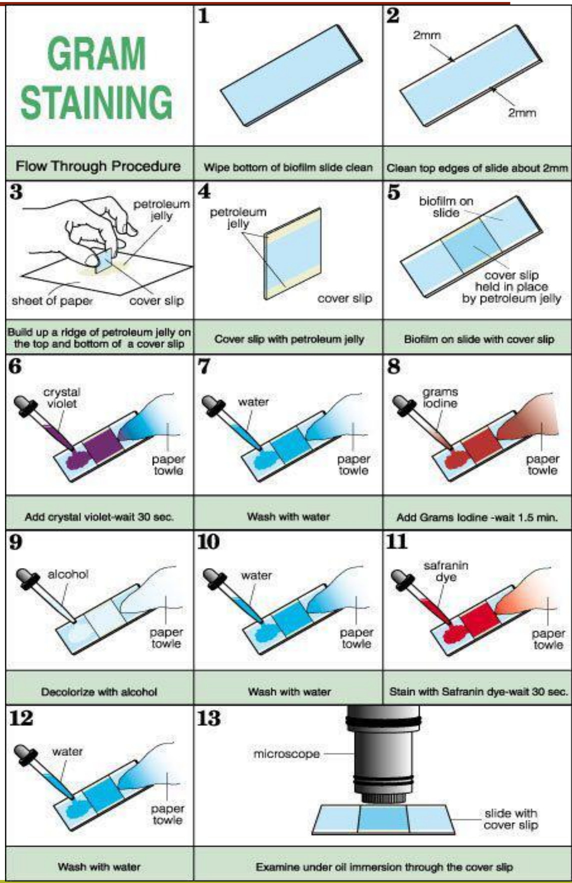
Rigid part , mucopeptide composed of alternating strands of *N- acetyl muramic acid* and *N- acetyle glucosamine* linked with peptide subunits.

Note : *Mycoplasma* is naturally have no cell wall.

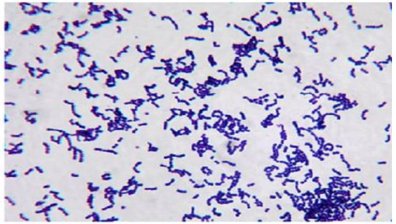


Gram Staining

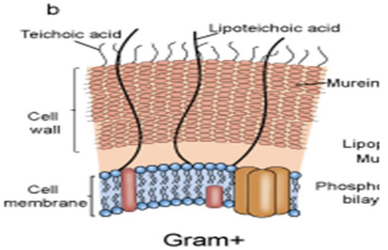




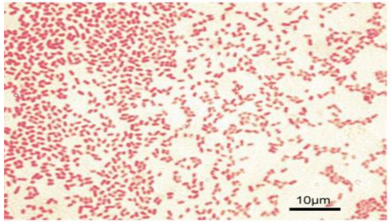
Types of bacteria



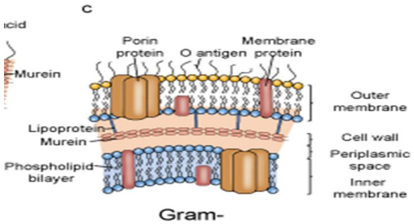
Gram Positive Bacteria



GRAM +VE BACTERIA	GRAM -VE BACTERIA
• stain blue/purple by Gram stain	• stain red by Gram stain
• Thick peptidoglycan	• Thin peptidoglycan
• Contains: - Teichoic acid : anchors cell wall to cell membrane , epithelial cell adhesion. - Antigens : polysaccharides (Lancefield), protein (Griffith)	• Outer membrane that contains : - specific proteins (porins) important in the transport of hydrophilic molecules - lipopolysaccharide (ENDOTOXIN) (the outer membrane of gram -ve bacteria)
• Closely associated with cytoplasmic membrane.	



Gram Negative Bacteria



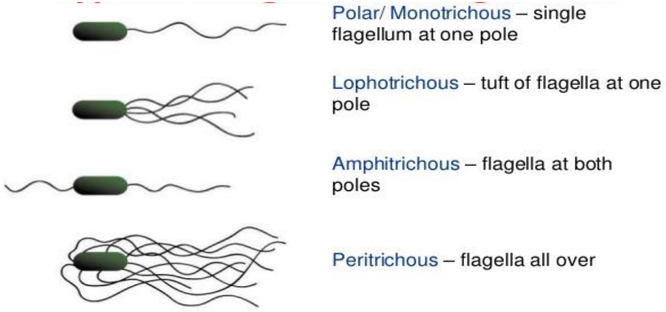
External structures of bacteria

★ Flagella:

- Helical filaments in shape.
- Composed of FLAGELLIN (protein).
- Found in both Gram (+) & Gram (-) bacteria.

★ Distribution:

- Monotrichous
- Lophotrichous
- Peritrichous



★ Function of Flagella:

- motility & chemotaxis.

Structure of Flagella:

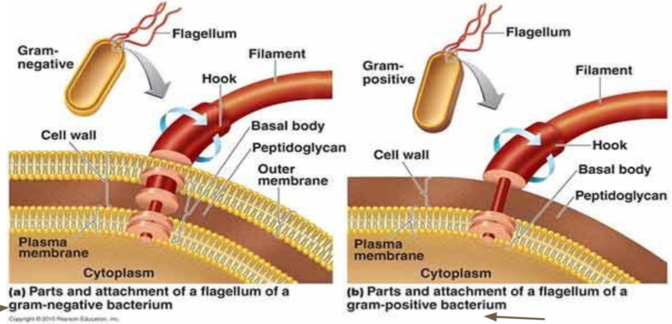
- Basal body: is a protein as rings on central rod.

(4 in Gram - & only 2 in Gram +)

The outer pair of rings it's only in Gram - (pushed through outer membrane).

Inner pairs are inserted into peptidoglycan & cytoplasmic membrane.

- Hook: a bent structure act as joint.
- Long Filament: Flagellin protein.



(a) Parts and attachment of a flagellum of a gram-negative bacterium

(b) Parts and attachment of a flagellum of a gram-positive bacterium

External structures of bacteria

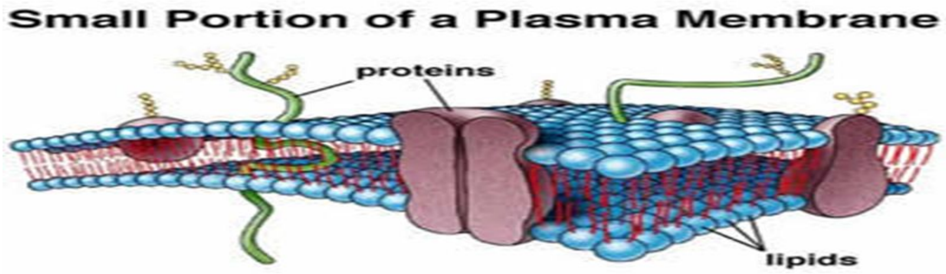
Organelle	Shape	Composition	Found in	Types	Function
Pili	Fine short filaments	Pilin (protein)	On the surface of Gram +ve & Gram -ve bacteria. (extruding from cytoplasmic membrane)	-Common pili (fimbriae): covers the surface. -Sex pili : in some bacteria only.	-Common pili: responsible for: adhesion & colonization. -Sex pili responsible for conjugation.
Capsules and slime layer	structures surrounding the outside of cell envelope.	Polysaccharide (in most bacteria) Polypeptide "Protein" (in some bacteria).	some strains within species produce capsule while others do not .	-	-Attachment -Protection from phagocytic engulfment. -Resistant to dryness. -Reservoir for certain nutrient. *not essential for viability.

Cytoplasmic Membrane (plasma 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

Spores of Bacteria

Small ,dense, metabolically inactive , non-reproductive structures produced by ***Bacillus & Clostridium.***

- Enables the bacteria to survive adverse environmental conditions. (rigid environments)
- Contain high concentration of **Calcium** dipicolonate.
- **Resistant to heat, dissecation & disinfectants.**
- Often remain **associated with the cell wall.**
- Spores germinate when growth conditions become favorable to produce **vegetative cells.**

تتبرعم

نامية-حية

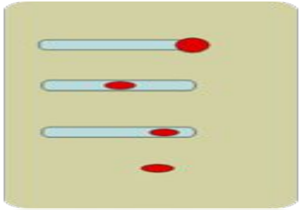
Internal Structures of Bacteria

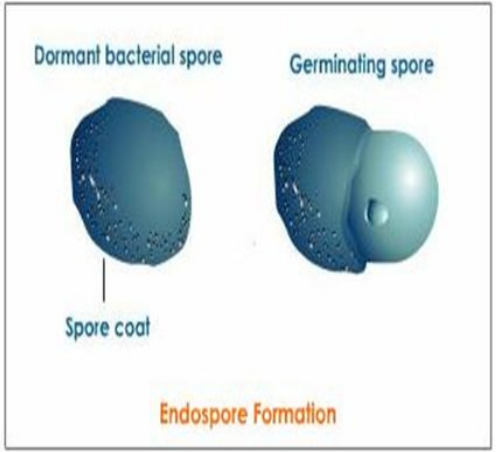
Spores of Bacteria

- **<u>Application in medical practice</u>** :

spore preparations used for checking the efficacy of **Autoclaves**, eg. *Bacillus subtilis & Bacillus stearothermophilus.*

Spores are <u>described</u> as: **Terminal** spores, **Sub-terminal** spores, **Central** spores.





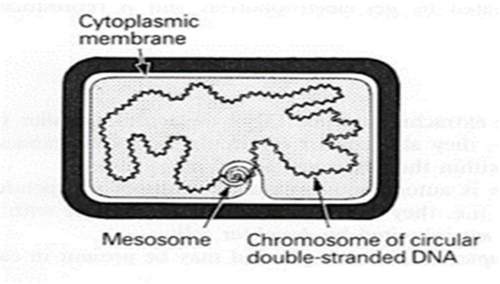
Internal structures of Bacteria

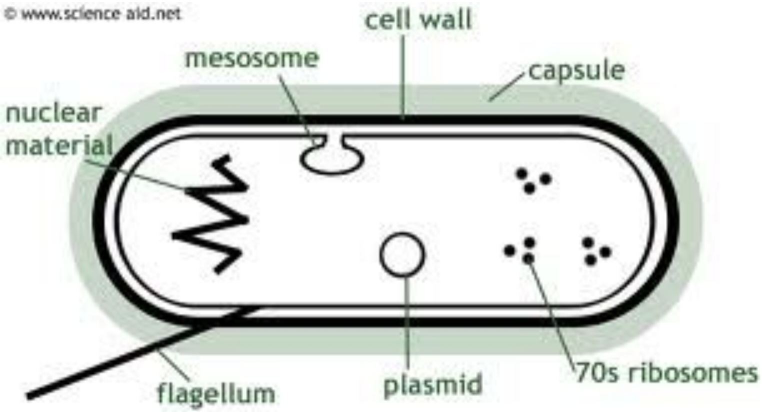
Mesosomes:

convoluted invaginations of cytoplasmic membrane.

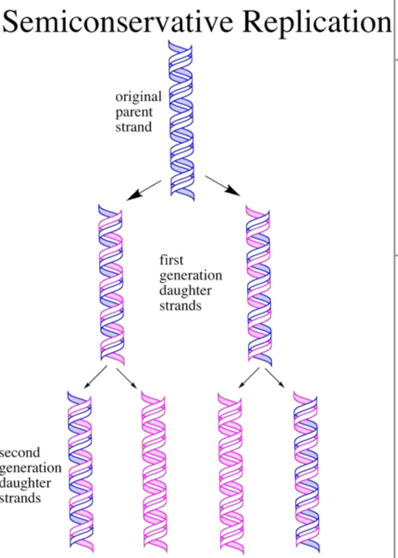
Function:

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

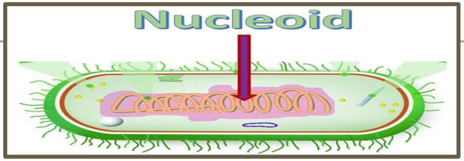




Internal structures of Bacteria



<u>Core of Bacteria</u> Composed of		
Cytoplasmic inclusions	**Nucleoid (Nuclear Body)** (note that we do not call it a nucleus)	**Ribosomes of Bacteria**
Are nutritional storage granules. <u>examples</u>: -Volutin -Lipid -Starch / or Glycogen	-single, circular chromosome (bacteria genome or DNA), (which is made of double stranded DNA). - <u>No</u> nuclear membrane -DNA undergoes **semi-conservative** replication , <u>bidirectional</u> from a fixed point.	-Distributed throughout the cytoplasm -Site of protein synthesis -Composed of RNA and protein.



Summary from 436

INTERNAL STRUCTURES OF BACTERIA

HOW?
By storing Genetic material

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).

Core of Bacteria

Cytoplasmic inclusions:
Nutritional storage granules examples:
- Volutin
- Lipid
- Starch / or Glycogen

Nucleoid (Nuclear Body) :
- Circular single stranded chromosome (bacteria genome or DNA)
- No nuclear membrane
- DNA undergoes semi conservative replication , bidirectional from a fixed point

Ribosomes of Bacteria:
- Distributed throughout the cytoplasm
- Site of protein synthesis
- Composed of RNA and protein

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, dissection & disinfectants
- Often remain associated with the cell wall
- 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.
- Spores are described as :

Central spores | Sub-terminal spores | Terminal spores

Bacterial Genetics: definitions

Genetics is the study of inheritance and variation.

•Genetic information encoded in DNA.

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

•**Phenotype:** expression of specific genetic material .

•**Wild type:** reference (parent) strain (لم تتعرض لأي طفرة)

•**Mutant:** progeny with mutation. (تعرضت لطفرات وتغيرات)

Function of genetic material:

1- Replication of the genome

2- Expression of DNA to mRNA then to protein>

Transcription translation

2 types of DNA in bacteria

•**Chromosomal**

•**Extra-chromosomal (Plasmid).** **(found in the bacterial cytoplasm and nobody know where it come from)**

Genetic variation in bacteria takes place by:

1- Mutations

2-Gene transfer

DNA types in the bacteria

Chromosomal

- Haploid, circular molecule of double stranded-DNA attached to cell membrane.
- No nuclear membrane (prokaryotes).
- DNA a double helical structure, genetic code in Purine and Pyrimidine bases of nucleotides that makes DNA strand. **(like human A T G C)**
- 3 bases comprise one code, each triplet codon codes for one amino acid.
- Replication is semi-conservative

Extra-chromosomal (Plasmid). (الخلية بدونها ممكن تعيش)

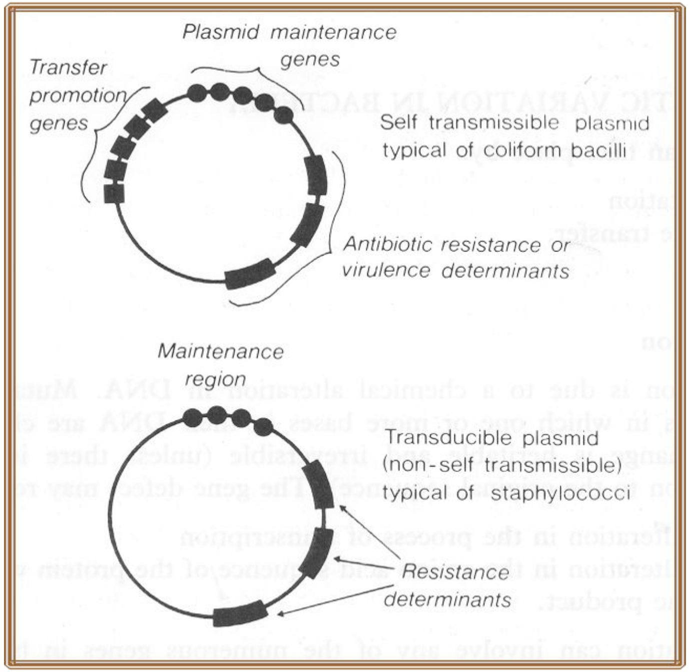
- Extra chromosomal DNA composed of double stranded-DNA. (in the cytoplasm)
- Found in most species of bacteria.
- Origin? (unknown)
- Govern their own replication
- Application :Genetic exchange, amplify genes. (مثل الهندسة الوراثية)
- Transfer by conjugation (تزاوج)
- Unrelated plasmids coexist together only. (في الخلية الوحدة ممكن يكون فيها أكثر من نوع)

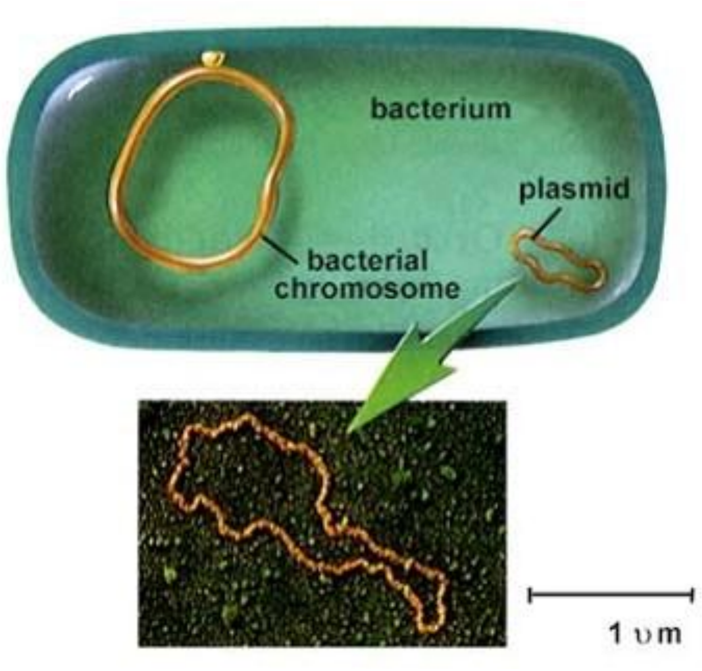
هي التي تجعل الخلية عدوانية ووحشية .

Type of plasmids

- **R-plasmids**: genes code for antibiotic resistance particularly Gram negative bacteria.
- **Col-plasmids:** in Enterobacteria, codes for extracellular toxins.
- **F-plasmids:** (fertility) factor, transfer of chromosome during mating .

Plasmids





One Bacteria can have more than one type of plasmids

Mutation

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

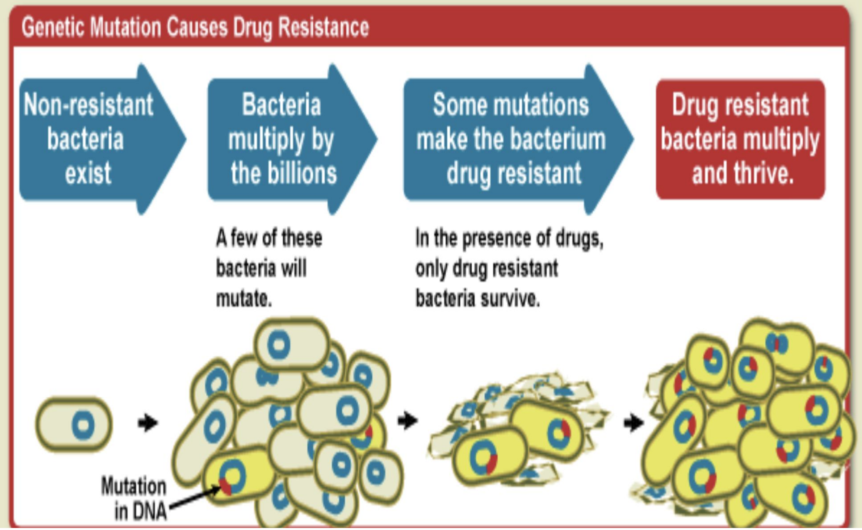
Genetic variation in bacteria

1. Mutation
2. Gene transfer

Mutation /gene defect leads to alteration in:

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

Mutation Causes Antimicrobial Resistance



Mutation

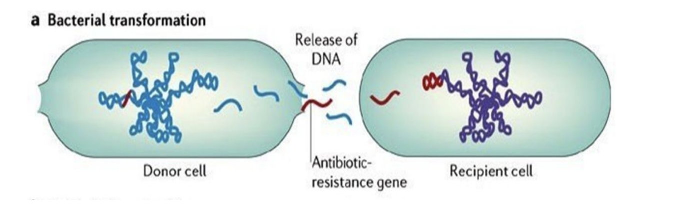
<u>Classification of Mutations:</u>

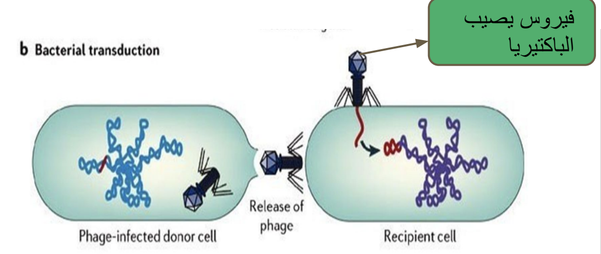
Depends on biological sequencing:

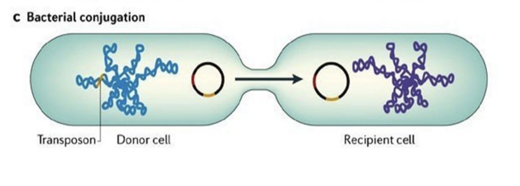
<u>**Resistance mutation**</u>	affects structure of cell protein. Main application in medical practice. Bacteria become resistant to antibiotics
<u>**Auxotrophic mutation**</u>	affects biosynthetic enzyme resulting in a nutritional requirement of mutant cell.
<u>**Lethal mutation**</u>	Leads to death of bacteria.

Gene transfer among bacteria (another way to change the genetic material other than mutations)

Transformation	Transduction	Conjugation
A fragment of exogenous naked bacterial DNA are taken up and absorbed into recipient cells.	Phage mediated transfer of genetic information from donor to recipient cells.	Major way bacteria acquire additional genes. Cell contact required and genes reside on plasmid resident within donor cells transfer to recipient cell (**mating**). Mediated by plasmid called F factor **(fertility).** 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.
Common in Haemophilus influenzae & Streptococcus Pneumoniae. ★ **Bacteria becomes resistant to Ampicillin.**	Beta – Lactamase production in Staphylococcus aureus : Bacteria becomes resistant to penicillin. Toxin production by Corynebacterium diphtheriae.	







Genetic Recombination:

An enzyme that destroys any foreign material

After gene transfer, there are **three** possible fates:

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

MCQs:

1/ Which of the following is incorrect?
Bacteria have..

a) no mitochondria
b) no sterols
c) no nuclear membrane
d) no plasmids

2/Tapered end bacteria are called:

a) bacilli
b) cocci
c) fusiform
d) vibrio

3/Cocci bacteria arranged in Palisades are called:

a) staphylococci
b) corynebacterium
c) streptococci
d) coccobacilli

4/Flagella distribution which is characterized by having only one at each pole is:

a) peritrichous
b) monotrichous
c) lophotrichous
d) amphitrichous

5/Bacteria replication takes place by..

a) meiosis
b) mitosis
c) binary fission
d) none of the above

6/Bacillus & Clostridium are resistant to heat, desiccation & disinfectants due to..

a) high conc of Na
b) high conc of Ca dipicolinate
c) low conc of Na
d) low conc of Ca dipicolonate

1/D
2/C
3/B
4/D
5/C
6/B

MCQs:

7/The type of plasmid that codes for extracellular toxins that can kill other bacteria is..

a) R plasmid
b) Col plasmid
c) F plasmid
d) None of the above

8/Outer membrane layer of cell wall is found in..
a) gram +ve
b) grams -ve
c) both
d) neither

9/How many chromosomes are there in bacteria?

a) 1
b) 2
c) 46
d) 23

10/Which of the following gene transfer mechanisms is common in Haemophilus influenzae & Streptococcus Pneumoniae.

a) transduction
b) transformation
c) conjugation
d) lysis

11/Antigenic determinants are found on:

a) cell wall
b) plasmid
c) plasma membrane
d) DNA

12/Porins are found in..

a) gram -ve
b) gram +ve
c) both
d) neither

7/B
8/B
9/A
10/B
11/A
12/A

T or F:

1/Peptidoglycan in gram positive bacteria is thinner than Gram negative bacteria

T/F

2/Antigens: anchor cell walls to cell membranes and are responsible for epithelial cell adhesion.

T/F

3/The bacterial chromosome is diploid linear and single-stranded

T/F

4/Bacteria can survive without plasmids.

T/F

SAQ:

1/What is the name of the bacteria that naturally has no cell wall? -

2/Alternating strands of N- acetyl muramic acid and N- acetyl glucosamine linked with peptide subunits, Make up..

3/What is the most common way genes resistant to antibiotics transfer among bacteria in hospitals?

4/When the gene is Stabilized by circulation in Genetic Recombination it becomes..

1/F 2/F 3/F 4/T

1/Mycoplasma 2/peptidoglycan 3/Conjugation 4/plasmid

Team Leaders:

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- ★ بدر القرني

Members:

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- ★ أميرة الزهراني
- ★ غادة السدحان
- ★ نجود العلي
- ★ جود الخليفة
- ★ دينا عورتاني
- ★ ريم بن ادريس
- ★ ريناد المطوع
- ★ سارة الهلال
- ★ طيبة الزيد
- ★ لينا النصار
- ★ ميسون آل تميم
- ★ نورة المزروع
- ★ سارة الخليفي

- ★ عبدالرحمن البديوي
- ★ مهند أحمد
- ★ فيصل القبلان
- ★ عيدالله العثمان
- ★ عبدالعزيز دهمش
- ★ بدر المهناء
- ★ عبدالله العيسى
- ★ عبدالرحمن الحواس
- ★ عبدالله الداود
- ★ محمد الشويعر
- ★ نايف سعود
- ★ فارس المبارك
- ★ عبدالله النويبت

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