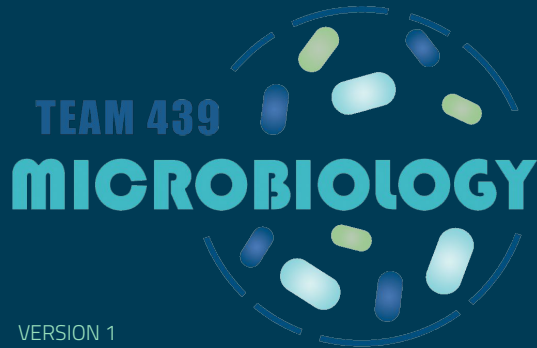


# Bacteria Structure and Genetics

Special Thanks to: **#Team438**



# Objectives

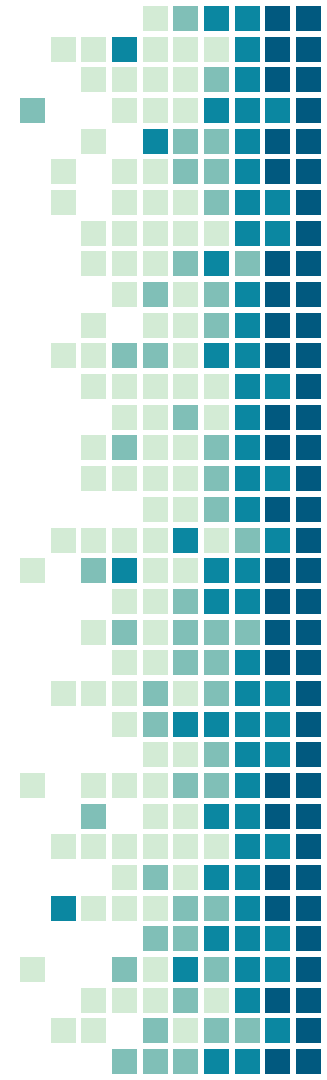
- ❖ Define the cellular organization of bacteria and recall the differences between Eukaryotes and Prokaryotes.
- ❖ Recall major structures of bacteria and its function.
- ❖ Describe the structure of cell wall of bacteria including the differences between Gram positive and Gram negative bacteria and 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.

## Colour index:

- **Red: Important**
- Grey: Extra info & explanation.
- **Purple: only in girl's slides.**
- **Green: Only in boy's slides.**
- 

Any future corrections  
will be in the editing  
file, so please check it  
frequently.

Scan the code  
Or click [here](#)



# Definition

Extra: sterols, also known as steroid alcohols, are a subgroup of the steroids, widely distributed in animal and plant lipids

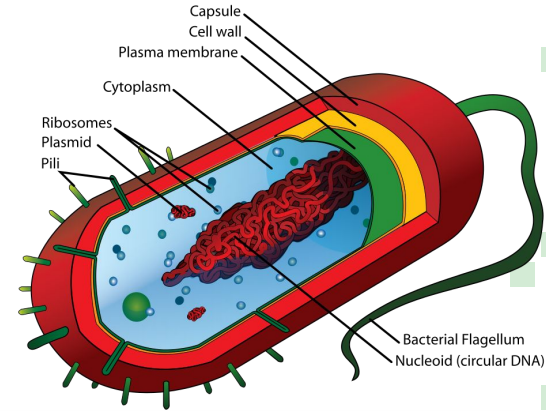


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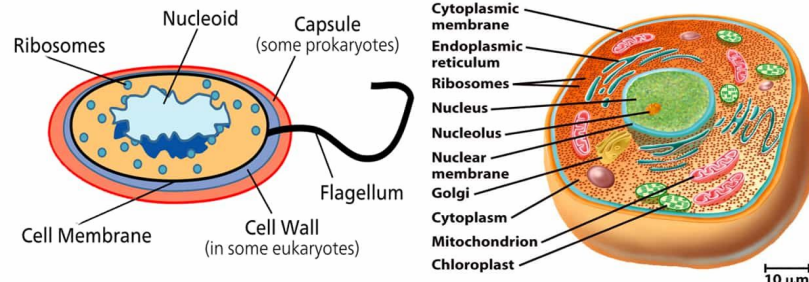
**Bacteria** is a **heterogenous** (diverse) group of unicellular organisms, about 1-8  $\mu\text{m}$  in diameter.

Bacteria is a **prokaryote**, it has a primitive nucleus: (بدائية النواة)

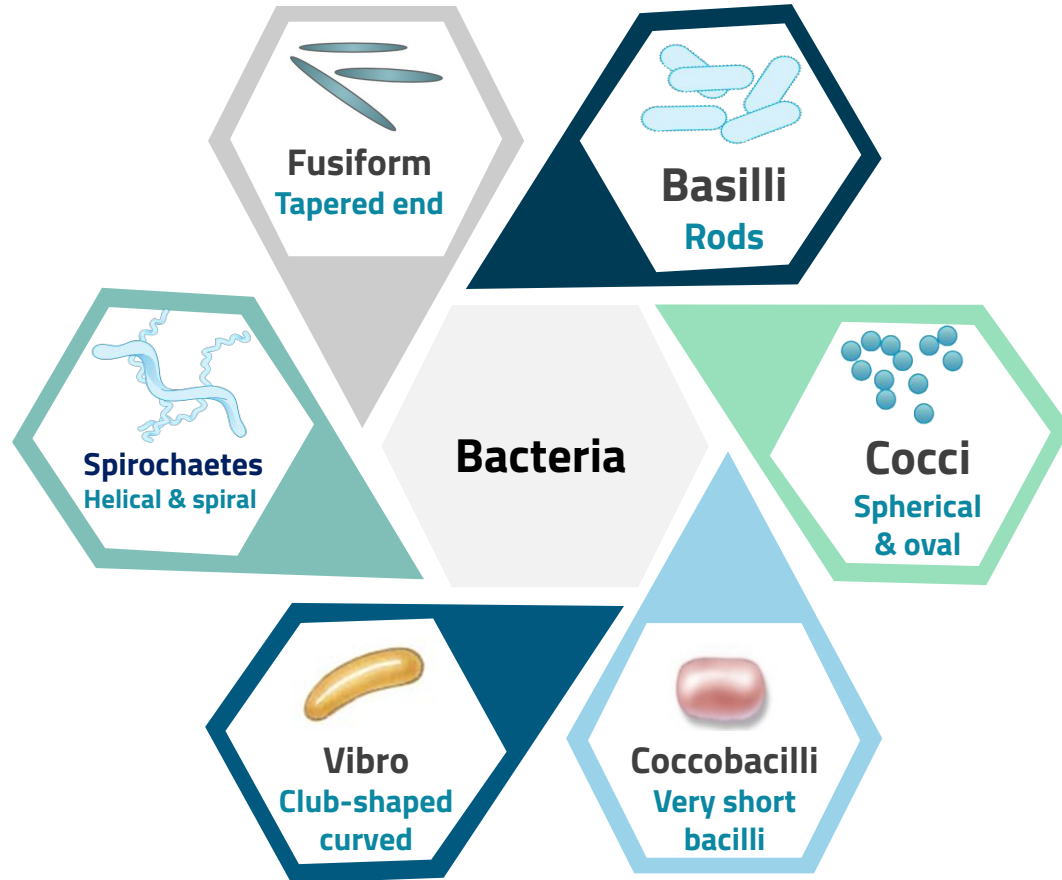
- It has one chromosome only.
- It has **plasmids** (an extra piece of DNA).
- No nuclear membrane.
- No mitochondria.
- No sterols

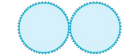
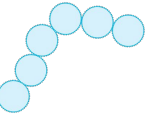
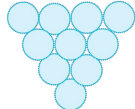
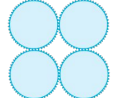



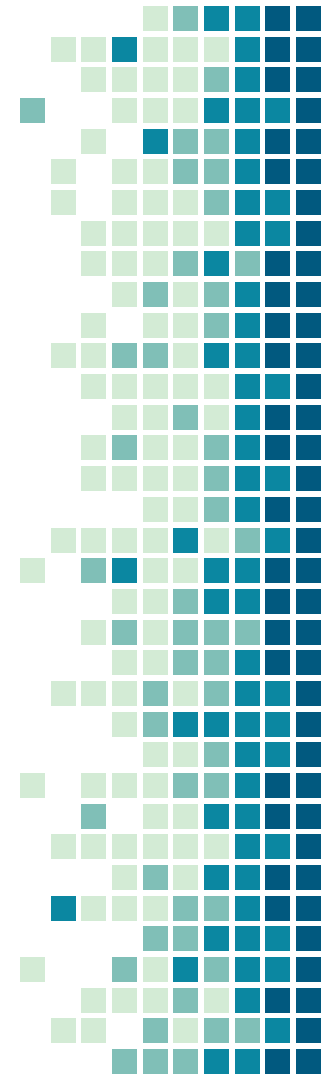
## Prokaryotes vs Eukaryotes



# Shapes & Types of Bacteria



Arrangement Among Cocci	
Pairs: Diplococci	
Chains: Streptococci	
Clusters: Staphylococci	
In four: Tetrad	
Palisades: Corynebacterium	



# Cell Wall of Bacteria

Bacteria are prokaryotic cells with a rigid cell wall that surrounds the cytoplasmic membrane and internal structures.

## Functions of Cell Wall:

Rigidity

Cell division

Protection

Porous (مسامي)

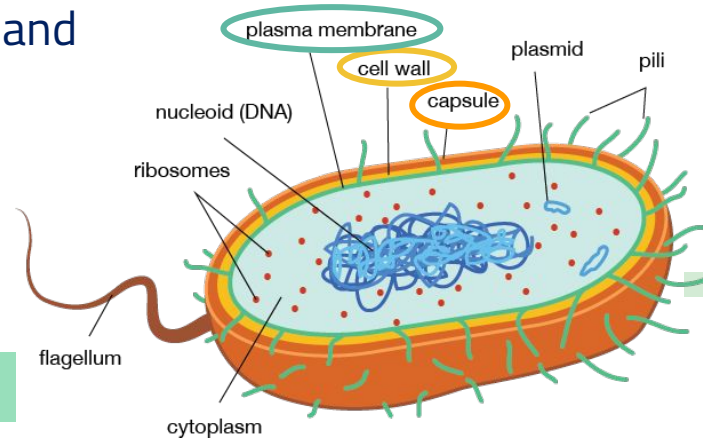
Permeable to low molecular molecules

Shape

Antigenic determinant

A part of an antigen that is recognized by the immune system

Outermost layer: **capsule**  
Middle layer: **cell wall**  
Innermost layer: **plasma membrane**



Extra: **antigenic determinant**, a site on the surface of an **antigen** molecule to which a single antibody molecule binds; generally an **antigen** has several or many different **antigenic determinants** and reacts with many different antibodies.

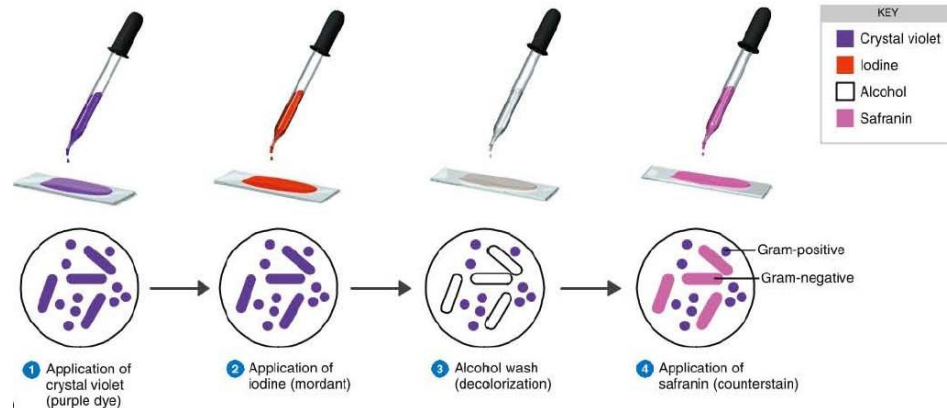
# Chemical Structure of Cell Wall

Bacterial cell wall is made of **Peptidoglycan**.

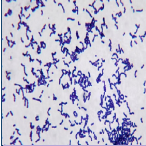

**Peptidoglycan:** (the rigid part of the cell wall) mucopeptide, a polymer that consist of sugars and amino acids, and the sugar component consists of alternating strands of **N-acetylglucosamine** and **N-acetylmuramic acid** with peptide subunits.

**Note:** **Mycoplasma** (a type of bacteria) naturally have no cell wall. (so, it does not stain with gram staining)

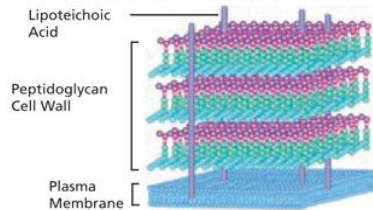
Extra: **Gram staining** is a common technique of four steps used to differentiate two large groups of bacteria based on their different cell wall constituents.



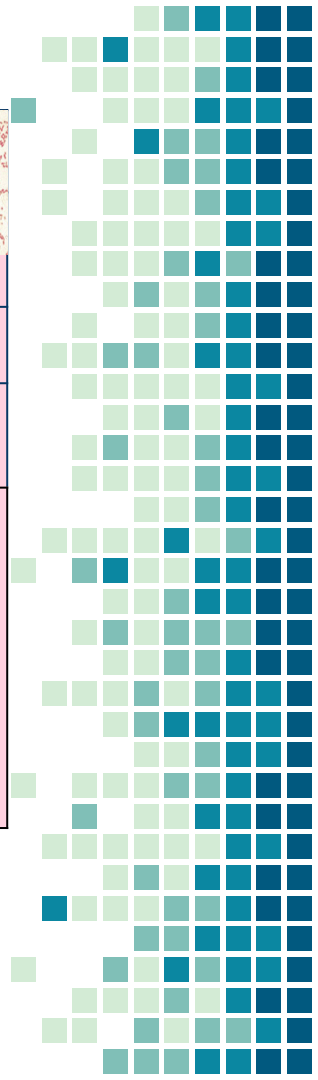
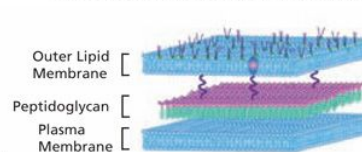
# Types of Bacteria, (gram stain) #Team38

 <b>Gram-Positive</b>	<b>Gram-Negative</b> 
<p><u>Retains</u> the crystal violet stain. Appears <b>purple</b> under microscope.</p>	<p><u>Do not retain</u> the crystal violet stain. Appears <b>pink</b> under the microscope.</p>
<p><b>Thick</b> peptidoglycan &amp; <b>multilayered</b>.</p>	<p><b>Thin</b> peptidoglycan &amp; <b>single layered</b>.</p>
<p>Outer membrane is <b>absent</b>.</p>	<p>Outer membrane is <b>present</b>. (surrounds peptidoglycan) فوق جدار الخلية</p>
<p><b>Cell wall</b> contains:</p> <ul style="list-style-type: none"> <li>- <b>Teichoic acids</b> a cell wall component that mediate the capacity of the bacteria to adhere to epithelial cells, and anchors cell wall to cell membrane.</li> <li>- <b>Antigens:</b> examples polysaccharides: (Lancefield) protein: (Griffith)</li> </ul>	<p><b>Outer membrane</b> contains:</p> <ul style="list-style-type: none"> <li>- Lipopolysaccharides (<b>Endotoxins</b>): are part of the outer membrane of the cell wall of <b>Gram-negative</b> bacteria. (In the case of infection, cause septic shock)</li> <li>- Specific proteins (<b>porins</b>) important in the transport of hydrophilic molecules.</li> </ul>

**Gram-Positive Bacterial Cell Wall**



**Gram-Negative Bacterial Cell Wall**



# External structures of bacteria: 1- Flagella

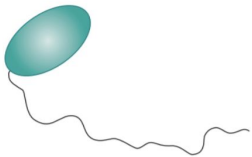
**Shape:** Helical filaments.

**Composed of:** a protein called **FLAGELLIN**.

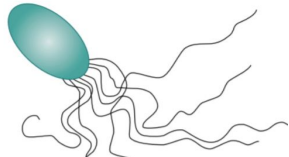
**Found in:** both gram positive & gram negative bacteria.

\* **Function:** **motility** and **chemotaxis**. (movement of an organism in response to a chemical stimulus).

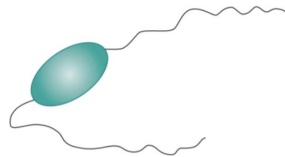
**Distribution:**



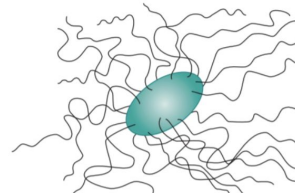
**Monotrichous**



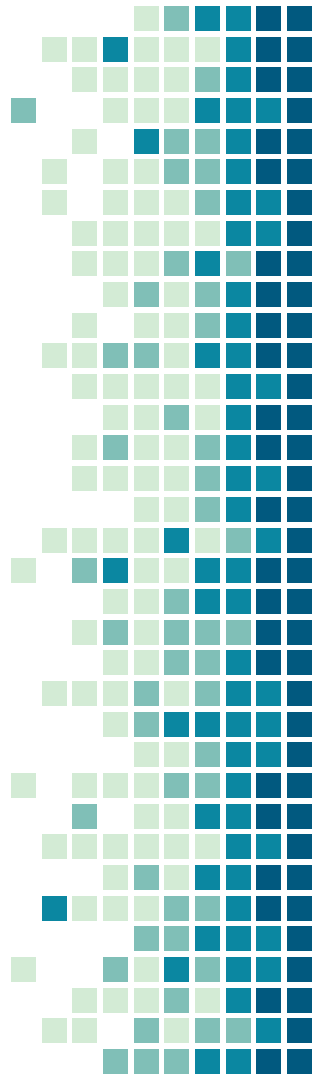
**Lophotrichous**



**Amphitrichous**



**Peritrichous**





# External structures of bacteria: 2- Pili

**Shape:** fine short filaments.

**Composed of:** a protein called **Pillin**.

**Found in:** the surface of many gram positive & gram negative bacteria.

## Types & Functions:

### Common pili

Also called fimbriae, covers the surface of the bacteria.

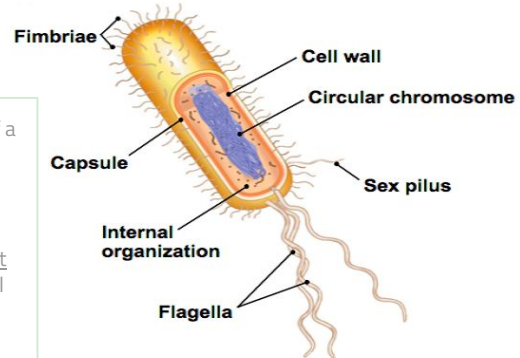
**Responsible for** adhesion (التصاق) & colonization (استعمار).

### Sex pili

In some bacteria only.

**Responsible for** conjugation (mating).

**Colonization:** presence of a microorganism on/in a host, with growth and multiplication of the organism, but without interaction between host and organism (no clinical expression, no immune response).



### Notes:

1- sex pili is only found in gram negative bacteria.

2- note that there is a difference between **conjugation** (تزاوج) and **reproduction** (تكاثر).

Conjugation is one of the ways bacteria transfer genes to each other, while reproduction is by binary fission.

# External structures of bacteria: 3- Capsules & Slime layer

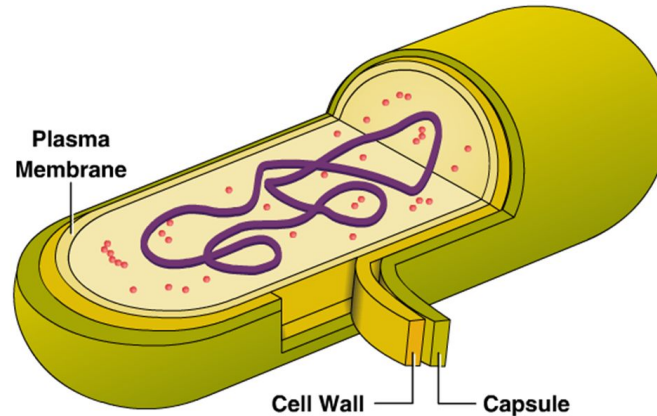
**Shape:** structures surrounding the outside of cell envelope.  
They can be seen by india ink or some special stains.

**Composed of:** mostly a polysaccharide, but in some bacteria it is composed of polypeptide (a protein).

**Found in:** only some strains within species, others might not have it.  
Note that it is **not** essential for cell viability.

## Function:

- Attachment (to the epithelial cells of human).
- Protection from phagocytic engulfment.
- Resistant to dryness.
- Reservoir (مخزن) for certain nutrients.



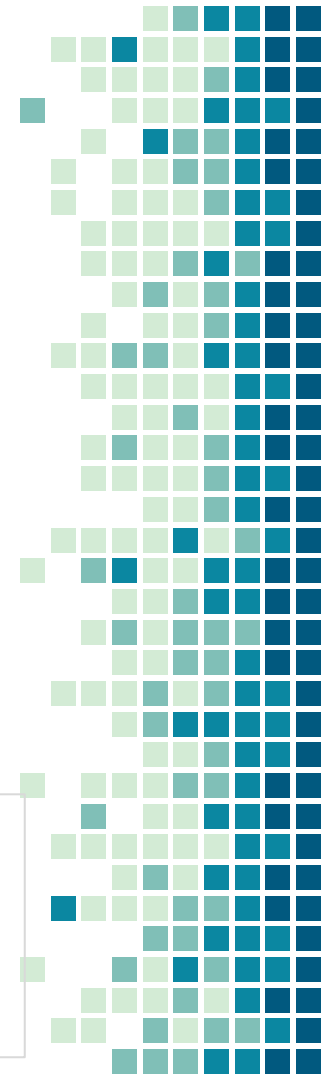
# Cytoplasmic Membrane (Plasma Membrane)

- 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.

## Notes:

Plasma membrane is the same in all creatures.

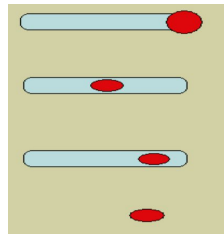
\* In addition to the **plasma membrane**, bacteria cells have a **cell wall**, **internal structures**, and **external structures**.



# Spores

Spores are small ,dense, **metabolically inactive** , non-reproductive structures produced by ***Bacillus & Clostridium***.

- Spores are hard because it contain a high concentration of calcium dipicolinate.
- It is **Resistant** to heat, desiccation (extreme dryness), and to disinfectants (مطهر).
- Spores enable the bacteria to survive extreme environmental conditions.
- Also, spores often remain **associated with the cell wall**.
- Spores germinate (تتبرعم) **when growth conditions become favorable** to produce vegetative cells (actively growing cell of bacterium).



Dormant bacterial spore



Spore coat

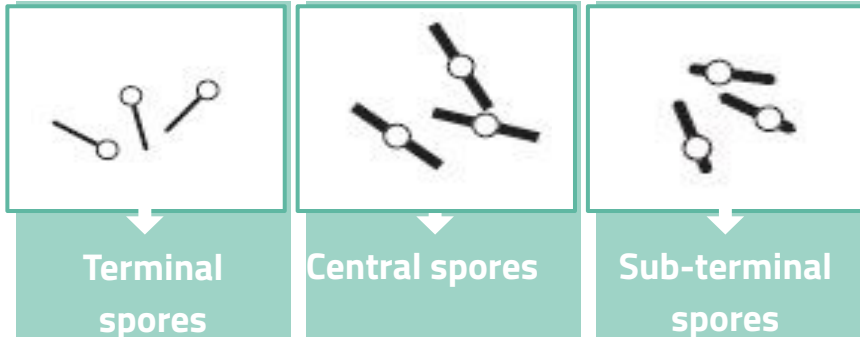
Germinating spore



Scan or Click

# Spores

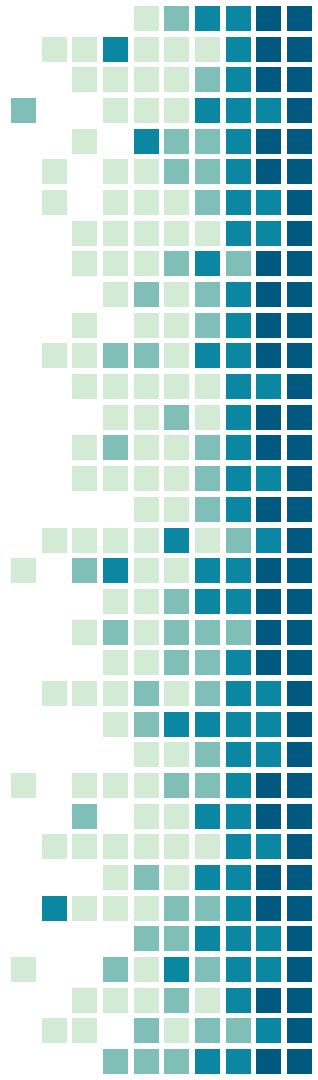
- Spores are described as:



- **Application in medical practice:**

Spore preparations used for checking the efficacy of **Autoclaves** (a pressure chamber that is used to sterilize equipment.) .

eg. **Bacillus subtilis** & **Bacillus stearothermophilus**.



# Internal structures of bacteria: Mesosomes

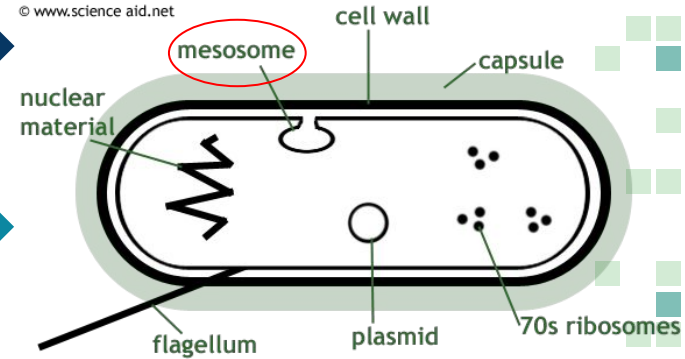
**Mesosomes** : convolutes invaginations of cytoplasmic membrane .

## Functions:

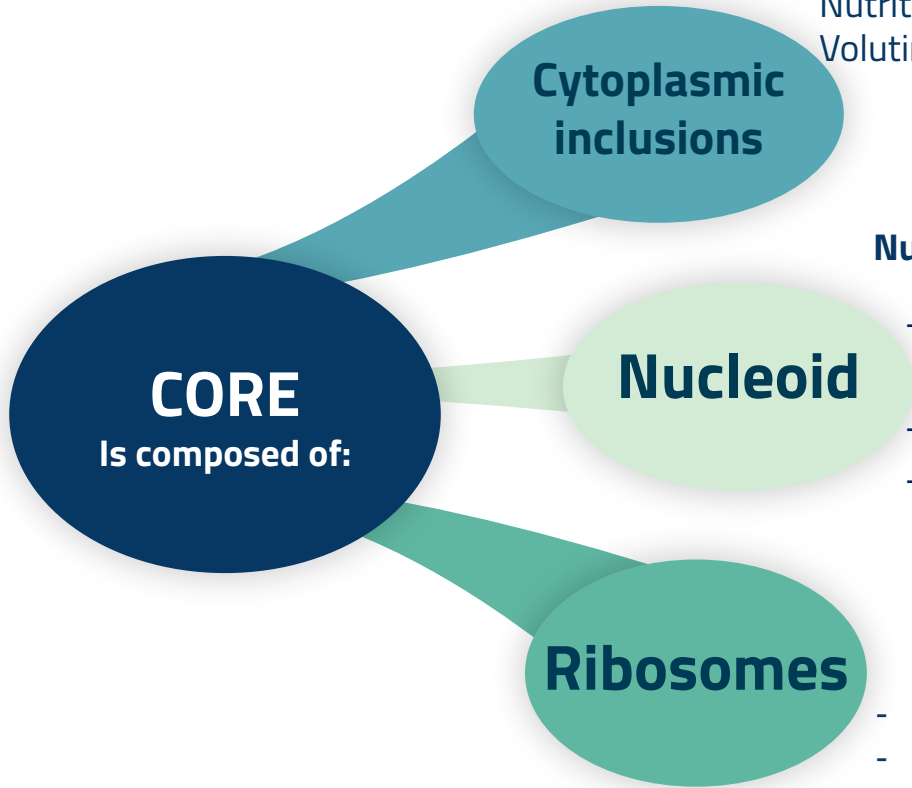
Involved in **DNA segregation** (separation) during **cell division** and **respiratory activity**.

Contain receptors involved in **chemotaxis**.

**Permeability barrier** (active transport of solutes).



# Internal structures of bacteria: Core of Bacteria

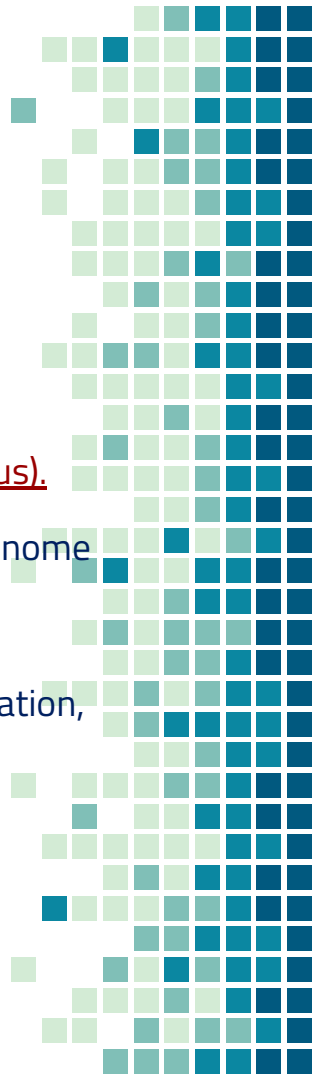


Nutritional storage granules such as Volutin, lipids, starch or glycogen.

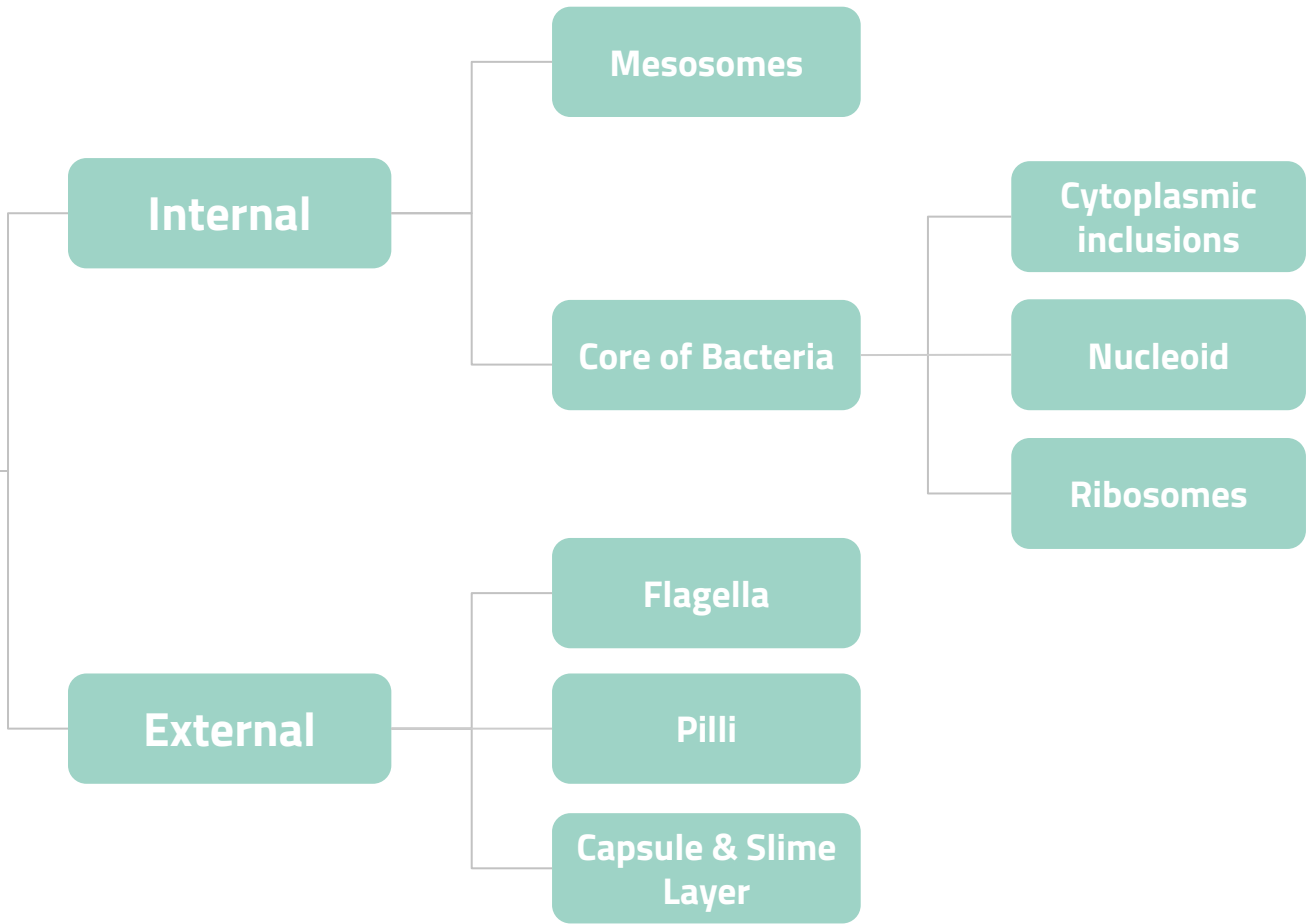
**Nuclear body** (note that we do not call it nucleus).

- single, circular, chromosome (bacteria genome or DNA), which is double stranded.
- No nuclear membrane.
- DNA undergoes **semiconservative** replication, **bidirectional** from a fixed point

- Sites of protein synthesis
- distributed throughout the cytoplasm.
- Composed of RNA and protein.



# Bacteria Structure





# Bacterial Genetics: Definition.

**Genetics** is the study of inheritance and variation.

- Genetic information is encoded in the DNA
- In bacteria, genetic variation is due to **Gene Transfer & Mutations**.

## Function of genetic material:

- Replication of the genome
- Expression of DNA to mRNA then to a protein. (transcription & translation)

**Genotype:** the complete set of genetic determinants of an organism (خريطة جينية)

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

**Wild type:** reference (parent) strain.

**Mutant:** progeny with mutation.



# Types of DNA in Bacteria

## Types of Bacterial DNA

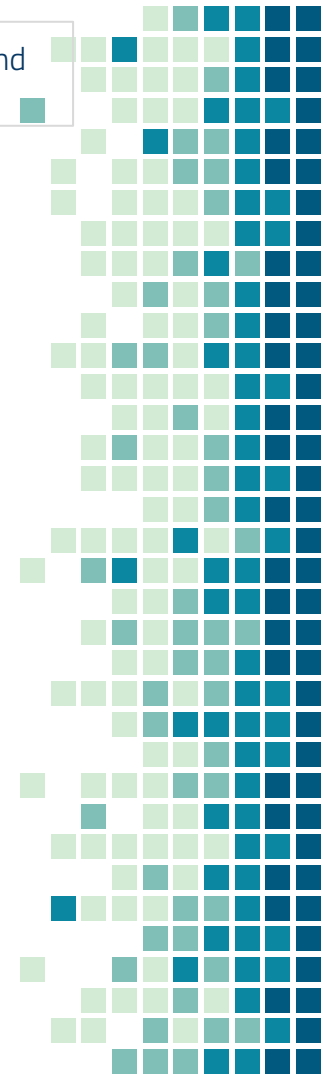
**Note:** plasmids are not necessary, and bacteria can live without them.

### Chromosomal

- Haploid (single, only one), circular molecule of **double stranded- DNA** attached to cell membrane.
- Genetic code in Purine and Pyrimidine bases of nucleotides that makes DNA strand.
- 3 bases comprise one code, each triplet codon codes for one amino acid.
- Replication is **semiconservative**, takes place by **binary fission**.

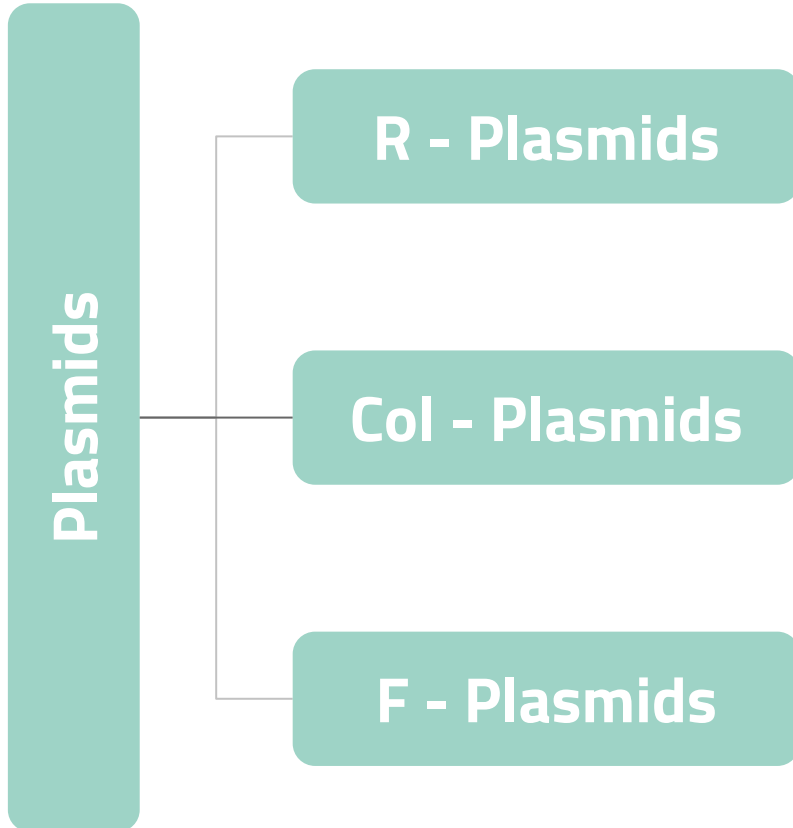
### Extrachromosomal (Plasmids)

- **Plasmids** are extrachromosomal DNA composed of double stranded DNA.
- Found in most species of bacteria, and the origin is unknown.
- Govern their own replication
- (إذا انقسمت البكتيريا كل واحدة تأخذ العدد نفسه من البلازميد)
- Application: in genetic exchange, amplify genes (هندسة وراثية)
- Transfer to other bacteria by **conjugation**. (Sex pili, remember?)



# Types of Plasmids

Team438: One Bacteria can have more than one type of plasmids



## R - Plasmids

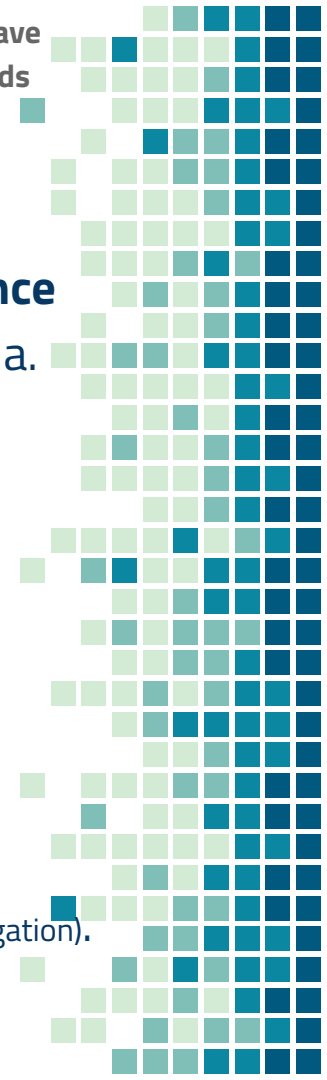
Genes code for **antibiotic resistance** particularly Gram negative bacteria.

## Col - Plasmids

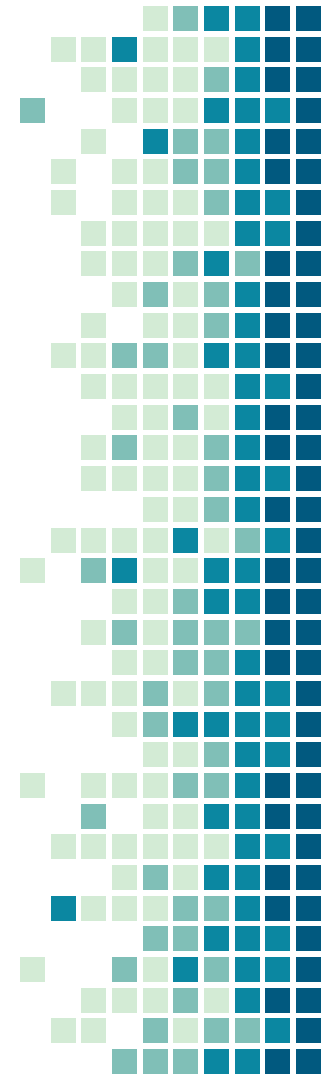
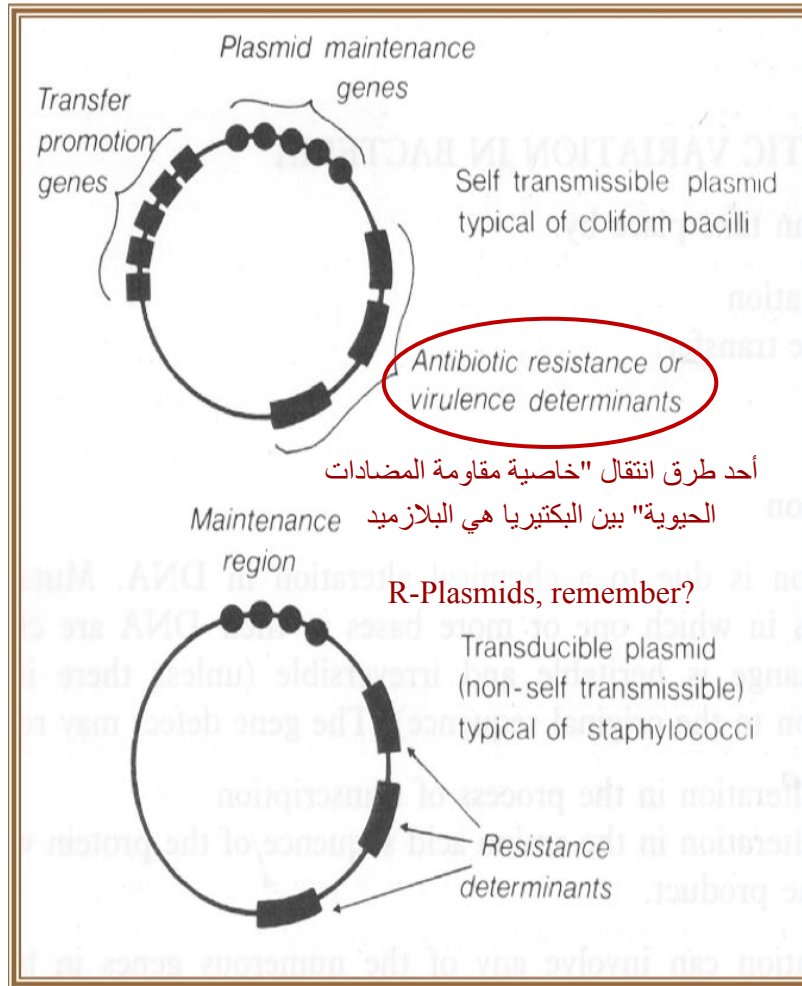
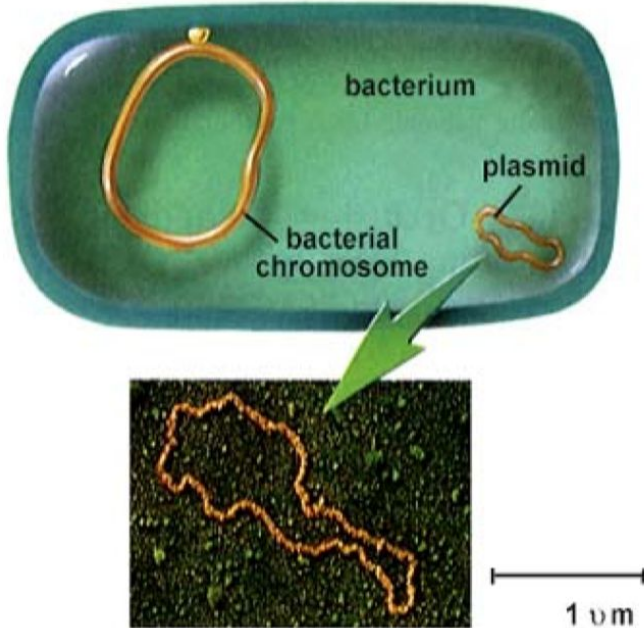
In Enterobacteria, codes for **extracellular toxins**.

## F - Plasmids

**(Fertility, F)** factor, transfer of chromosome during mating (conjugation).



# Plasmids, contd..

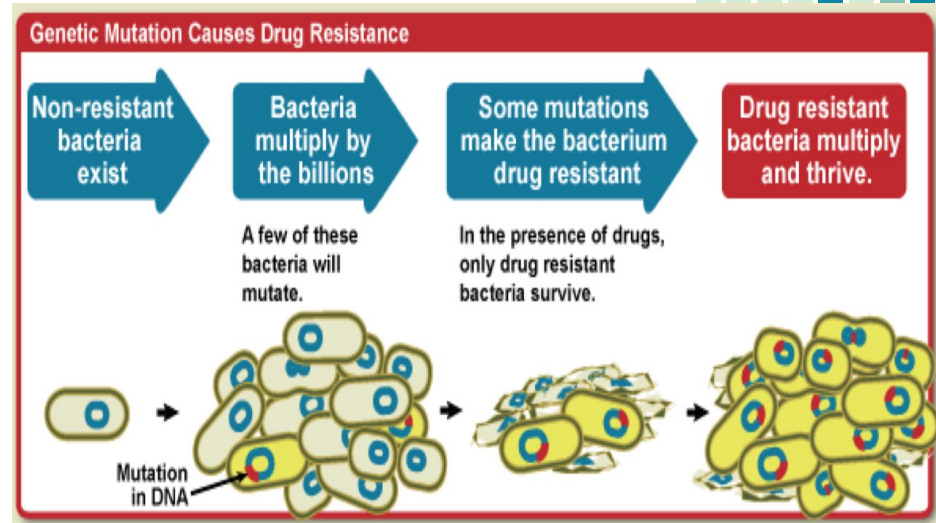


# Mutation

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

## Mutation / gene defect leads to alteration in:

- Transcription.
- Amino acid sequences.
- Function eg. **Bacteria become resistant to antibiotics.**



# Mutation, classification.. #Team38



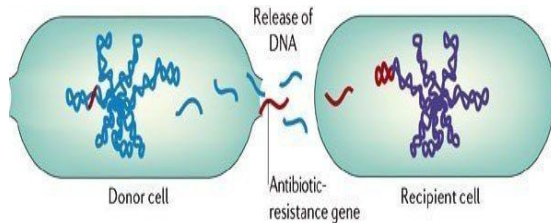
Depends on biological sequencing,

Extra\Note: not all mutations are bad for the bacteria, some might actually be beneficial.

<b>Resistance mutation</b>	affects structure of cell protein. <u>Main application in medical practice.</u> Bacteria become more resistant to antibiotics
<b>Auxotrophic mutation</b>	affects biosynthetic enzyme resulting in a nutritional requirement of mutant cell (unable to synthesize an essential compound).
<b>Lethal mutation</b>	Leads to death of bacteria.

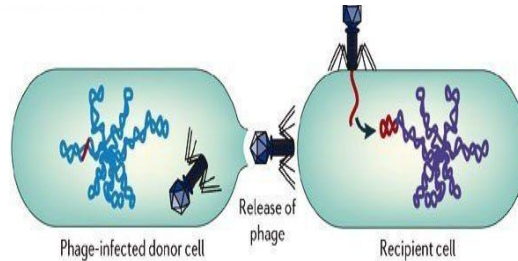
# Gene Transfer Among Bacteria

## Transformation



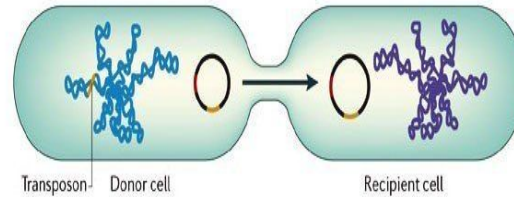
A fragment of exogenous naked bacterial DNA are taken up and absorbed into recipient cells.

## Transduction



Phage mediated transfer (by virus) of genetic information from donor to recipient cells.

## Conjugation



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



Scan or Click

# Gene Transfer Among Bacteria, contd..

## Transformation

- Common in *Haemophilus influenzae* & *Streptococcus pneumoniae*.
- Bacteria become resistant to Ampicillin.



Scan or Click

## Transduction (Phage, a virus)

Examples:

- Beta – Lactamase (enzyme) production in *Staphylococcus aureus*: Bacteria becomes resistant to penicillin.
- Toxin production by *Corynebacterium diphtheriae*.

## Conjugation (mating)

Major way bacteria acquire additional genes.

- **Plasmid mediated** (E factor)

The most common way of transfer of genetic resistance to antibiotics among bacteria in hospitals. (R-Plasmids)

**Note:** when bacteria gain “antibiotic resistance” it is gained either by **mutations**, or by acquisition of new genetic material (**genetic transfer**)





# Genetic Recombination

After gene transfer, there are three possible fates:

1-Exogenous DNA degraded by **nuclease** (enzyme).

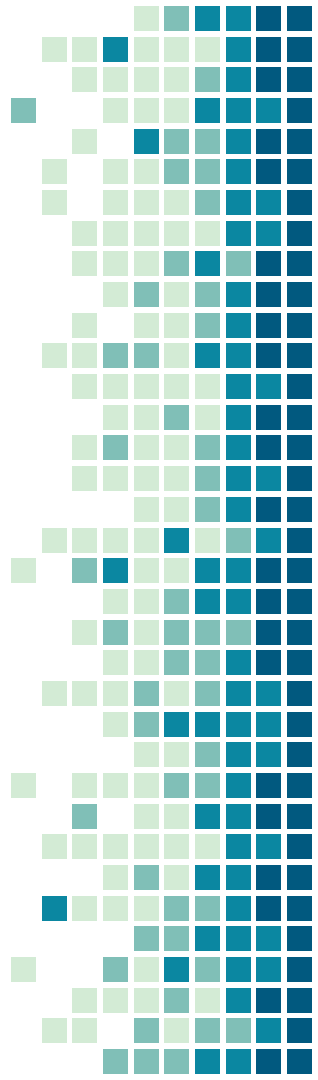
(الـDNA اللي جاي من خارج الخلية البكتيرية يتم تحليله من قبل انزيم nuclease)

2-Stabilized by circulation and become **plasmid**.

(يصير دائري ويتحول إلى بلازميد)

3- Form a partially **hybrid chromosome** with segment derived from each source.

(تندمج قطعة الكروموسوم الجديدة بالأصلية ويصير اسمه hybrid chromosome)



# MCQs

**1-Bacterial spores can survive harsh environmental conditions due to :**

- a) The presence of calcium dipicolinate
- b) The presence of presence of lipoteichoic acid
- c) The presence of calcium disodium edetate
- d) The presence of flagellin protein

**2-Which of the following is true about bacteria?**

- a) They have no cytoplasmic membrane
- b) They reproduce by binary fission
- c) All of them have an outer membrane
- d) Some of them have mitochondria

**3-Genetic material in bacteria is in the...**

- a) Plasmid & nucleus
- b) Plasmid & nucleoid
- c) Plasmid & nucleolus
- d) Bacteria contain no genetic material

**4-Which of the following is used to check the efficacy of autoclaves:**

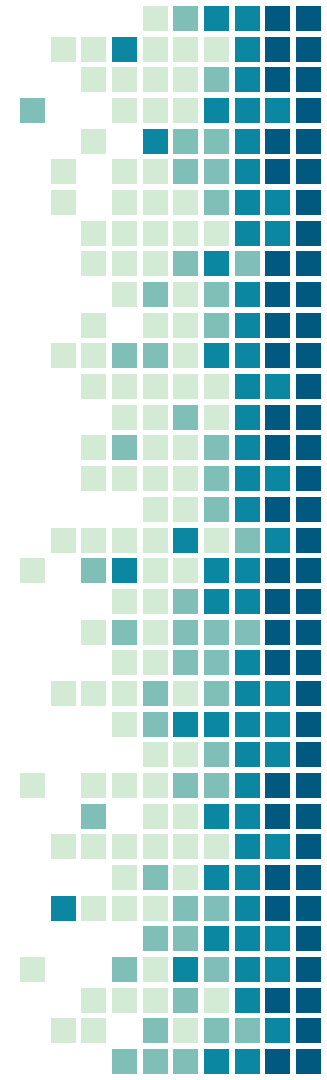
- a) Bacillus subtilis & Bacillus stearothermophilus
- b) Mycoplasma
- c) Staphylococcus aureus
- d) Corynebacterium diphtheriae

**5-Which of the following flagella have a distribution of a tail on both sides?**

- a) Monotrichous
- b) Peritrichous
- c) Lophotrichous
- d) Amphitrichous

**6-Which external structure in bacteria acts as a reservoir for a certain nutrient?**

- a) Capsules and Slime layer
- b) Pili
- c) Flagella
- d) none of the above



g-2  
5-p  
4-a  
3-b  
2-q  
1-a

# MCQs

**7-The name of the very short bacilli bacteria is?**

- a) Basilli
- b) Cocci
- c) Coccobacilli
- d) Vibrio

**8-When a fragment of exogenous naked bacterial DNA is taken up and absorbed into recipient cells this is called?**

- a) Transformation
- b) Transduction
- c) Conjugation
- d) Autoclaves
- e) Mutation

**9-In Enterobacteria, what codes for extracellular toxins?**

- a) R - Plasmids
- b) Col - Plasmids
- c) F - Plasmids
- d) C - plasmids
- e) Endotoxins

**10-In bacteria, it is the inheritable changes in the structure of genes (DNA) ?**

- a) Transformation
- b) Inheritable Disease
- c) Genetic disease
- d) Mutation
- e) Conjugation

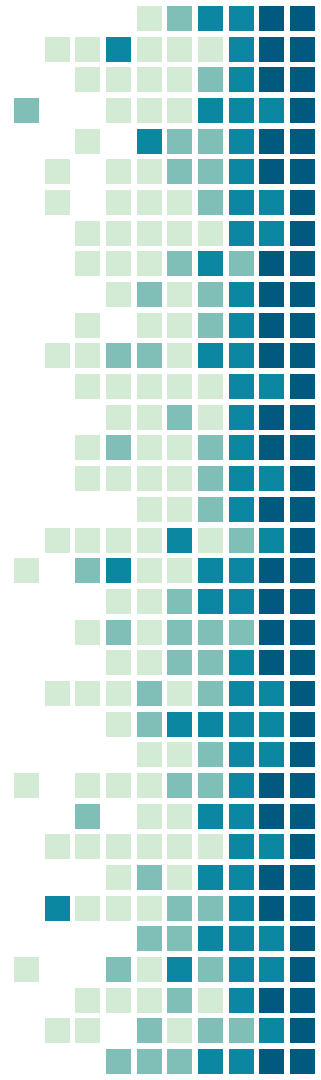
**11-Bacteria is a ..... group of unicellular organisms**

- a) Heterogenous
- b) Homogeneous
- c) spherical
- d) Round shape

**12-Endotoxins are found in....**

- a) Cell wall of all bacteria
- b) Cell wall of Gram-negative bacteria
- c) Cell wall of Gram-positive bacteria
- d) Outer membrane of Gram-negative bacteria
- e) Outer membrane of Gram-positive bacteria

p-21  
a-11  
p-01  
p-6  
a-8  
7-c

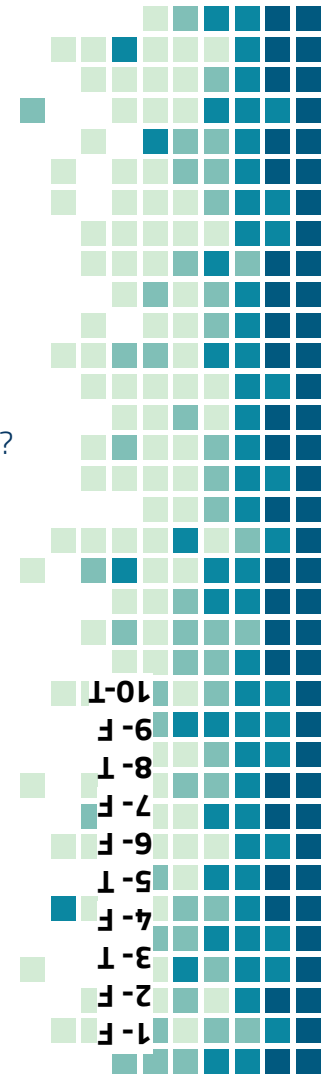


# T & F

1. Resistance mutation leads to death of bacteria. ( ).
2. Common pilli is responsible for conjugation between cells. ( ).
3. In mesosomes, there are receptors that are involved in chemotaxis ( ).
4. R-Plasmids code antibiotic resistance in Gram+ bacteria. ( ).
5. In transduction, toxins are produced by corynebacterium diphtheriae. ( ).
6. In hospitals, transduction is the most common way for transferring genetic resistance to antibiotics. ( ).
7. Flagella is only found in Gram+ ( ).
8. Mutations can lead to alteration in amino acid sequence. ( ).
9. Transduction is a plasmid mediated transfer of genetic material in bacteria. ( ).
10. Bacteria can survive without plasmids ( ).

# SAQ

- 1- List the three possible fates that bacteria might face after genetic recombination (gene transfer).
- 2- Name the bacteria that does not have a cell wall.
- 3- Capsules and slime layer, what are they composed of?
- 4- List the four possible distributions of flagella.
- 5- List the functions of the cell wall.
- 6- The core of bacteria is composed of,...?
- 7- What are the main differences between prokaryotes and eukaryotes?



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