

Microbiology

team 436



MEDICINE
KING SAUD UNIVERSITY

MICROBIOLOGY

Lecture : 1

BACTERIAL STRUCTURE AND GENETICS

IMPORTANT.
DOCTORS NOTES.
EXTRA INFORMATION.

Objectives-Bacterial Structure & function:

- Define the cellular organization of bacteria and know the differences between Eukaryotes and Prokaryotes. (S 3 +4)
 - Know major structures of bacteria and its Function. (4-6)
 - Know the structure of cell wall of bacteria including the differences between Gram positive and Gram negative bacteria and main Functions (S 6-8).
 - Know the external structures of bacteria with and functions .(9 - 11)
 - Know the cytosol and internal structures of bacteria .(12 and 13)
 - Describe bacterial spores and its application in the practice of medicine.(12)

Objectives- Bacterial Genetics:

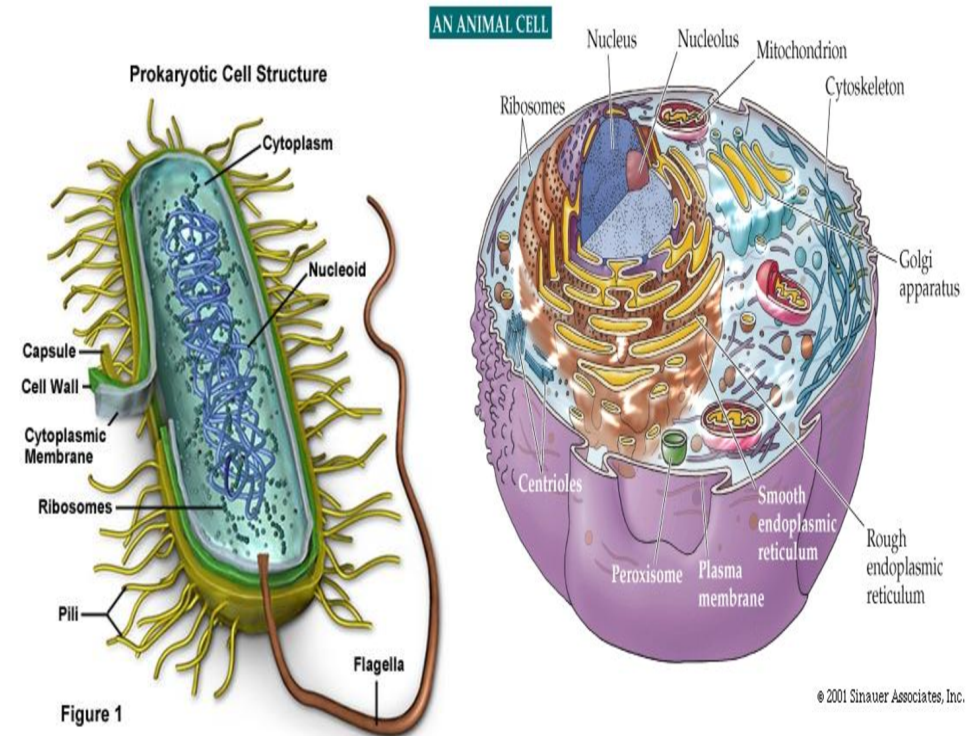
- Know basic information about bacterial genetics and replication of bacteria .(14)
- Describe plasmids , its origin , types and its importance in clinical practice.(15 and 17)
- Recalls genetics variations, including ; mutation and mechanisms of gene transfer and its implication on bacterial resistance to antimicrobial agents.(18 -25)

أمام كل هدف من الأهداف
أرقام السلايدات التي تتعلق فيه

Differences between eukaryotes and prokaryotes

Characteristic	Prokaryotes	Eukaryotes
Size of cell	Typically 0.2-2.0 μm in diameter	Typically 10-100 μm in diameter
Nucleus	No nuclear membrane or nucleoli (nucleoid)	True nucleus, consisting of nuclear membrane & nucleoli
Membrane-enclosed organelles	Absent	Present; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria & chloroplasts
Flagella	Consist of two protein building blocks	Complex; consist of multiple microtubules
Glycocalyx	Present as a capsule or slime layer	Present in some cells that lack a cell wall
Cell wall	Usually present; chemically complex (typical bacterial cell wall includes peptidoglycan)	When present, chemically simple
Plasma membrane	No carbohydrates and generally lacks sterols	Sterols and carbohydrates that serve as receptors present
Cytoplasm	No cytoskeleton or cytoplasmic streaming	Cytoskeleton; cytoplasmic streaming
Ribosomes	Smaller size (70S)	Larger size (80S); smaller size (70S) in organelles
Chromosome (DNA) arrangement	Single circular chromosome; lacks histones	Multiple linear chromosomes with histones
Cell division	Binary fission	Mitosis
Sexual reproduction	No meiosis; transfer of DNA fragments only (conjugation)	Involves Meiosis

Prokaryotic vs Eukaryotic Cells



****Cell wall present in all prokaryotes and it consist of peptidoglycan
It present in some eukaryotes ,like , plants and it consist of cellulose in plants**

لم يذكر الفرق في السلايدات الأساسية ولكن مذكورة في الأهداف*

Definition:

Bacteria : **Is a heterogenous** group of unicellular organisms , about 1 -8 μm in diameter.All bacteria is a **prokaryote**.

heterogenous : two or more things are unlike in substance or nature, as in a *heterogenous* mixture containing two substances that do not totally combine. (from a dictionary)

Some Characteristics..

Has a primitive nucleus

one chromosome
(floating in the cytoplasm)

No nuclear membrane

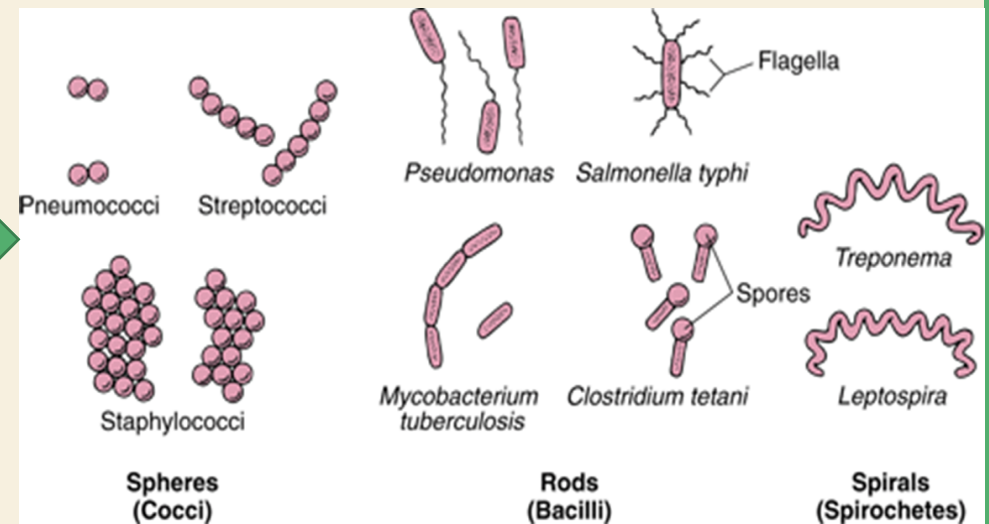
No mitochondria

No sterols

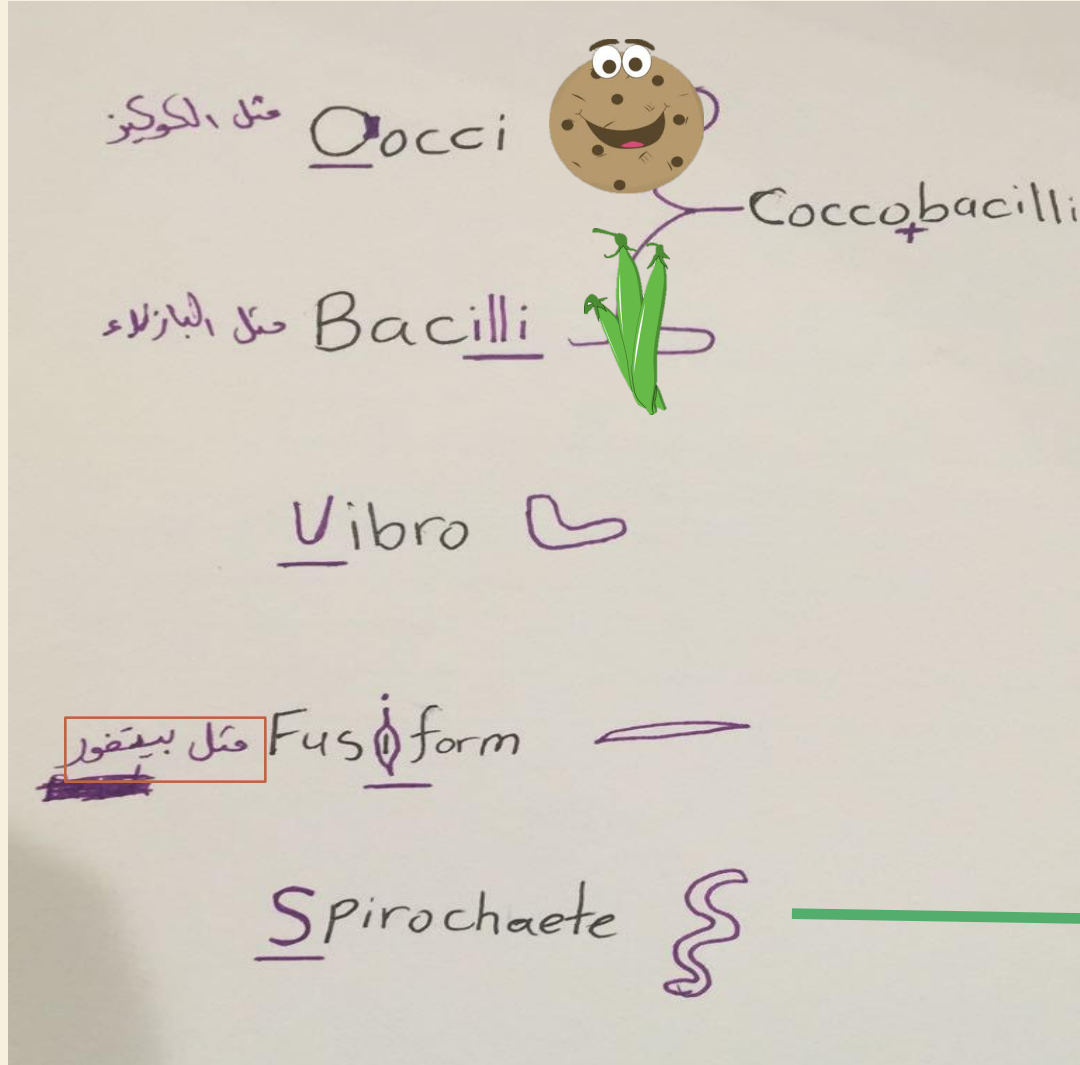
Bacteria contain **PLASMIDES** which is extra piece of **DNA**

Shapes of bacteria

Spherical / Oval \rightarrow .Cocci
Rods \rightarrow Bacilli
Very short Bacilli \rightarrow Coccobacilli
Tapered end \rightarrow Fusiform
Club-shaped / Curved \rightarrow Vibrio
Helical / Spiral \rightarrow .Spirochaetes



لزيادة الفهم

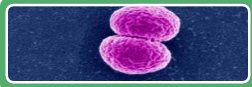


مثل بطاطس تشيتوس
اللولبي



شكر خاص :
لمنيرة الضفيان
و
روان القحطاني

Arrangement of bacteria:



Pairs.....Diplococci



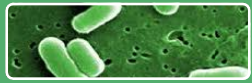
Clusters.....Staphylococci



Chains.....Streptococci



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
because of
peptidoglycan

Shapes
bacteria

Protection

Porous /
permeable to low
molecular weight
molecules

Cell division

Antigenic
determinants
(receptor)

**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 😊

***Note : *Mycoplasma* is a bacteria that is naturally have no cell wall.**

Chemical structure of bacterial cell wall:

Peptidoglycan :

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

Two groups of bacteria depending on reaction to GRAM STAIN:

1. **GRAM POSITIVE BACTERIA:** stain **blue/purple** by Gram stain

2. Peptidoglycan **thicker** than Gram negative bacteria.

3. Closely associated with cytoplasmic membrane

4. **Teichoic acid** : anchors cell wall to cell membrane , epithelial cell adhesion.

5. **Antigens** :
*polysaccharides(Lancefield)
*protein(Griffith)

1. **GRAM NEGATIVE BACTERIA:** stain **red** by Gram stain

2. **Thin** Peptidoglycan

3. **outer membrane**(only in negative) contains: specific proteins (porins) important in the transport of hydrophilic molecules lipopolysaccharide & lipid (**ENDOTOXIN**)

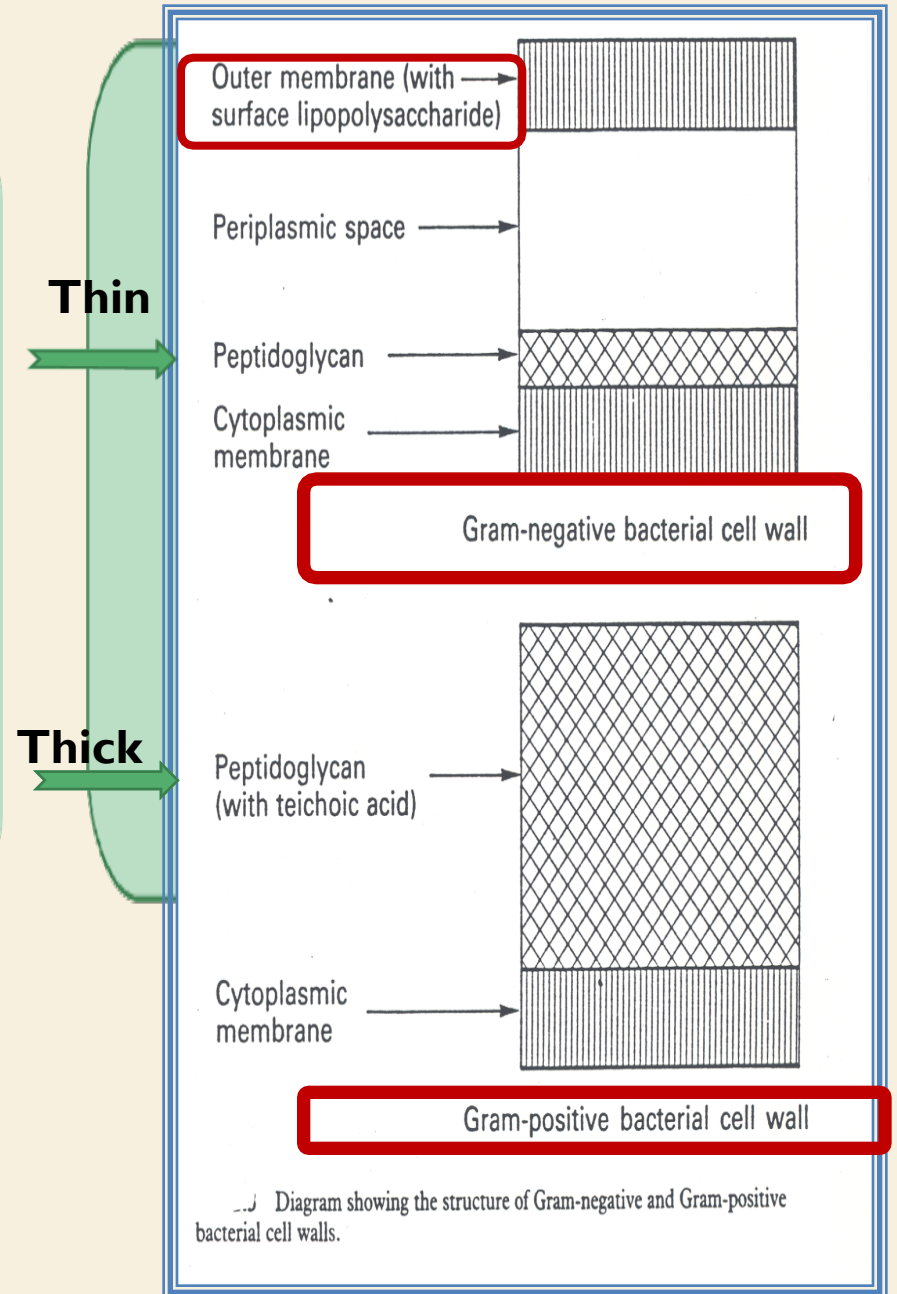
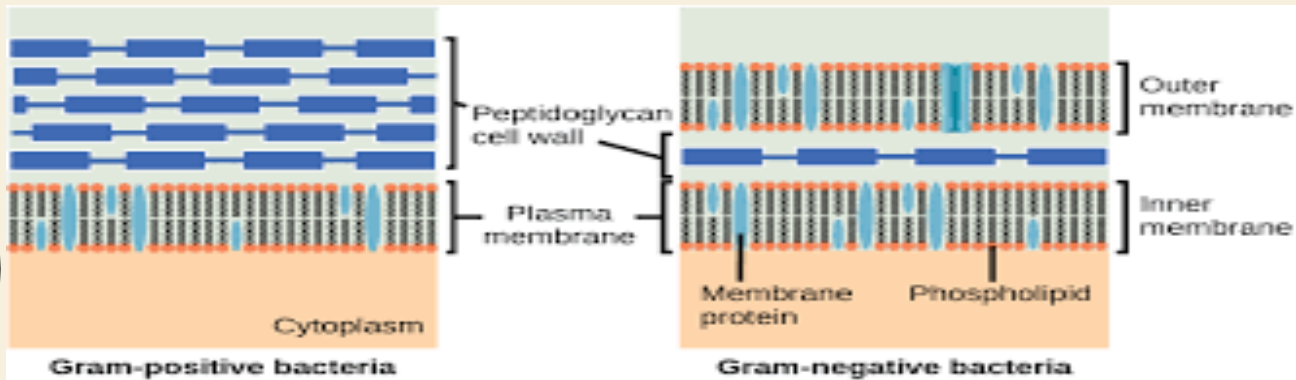
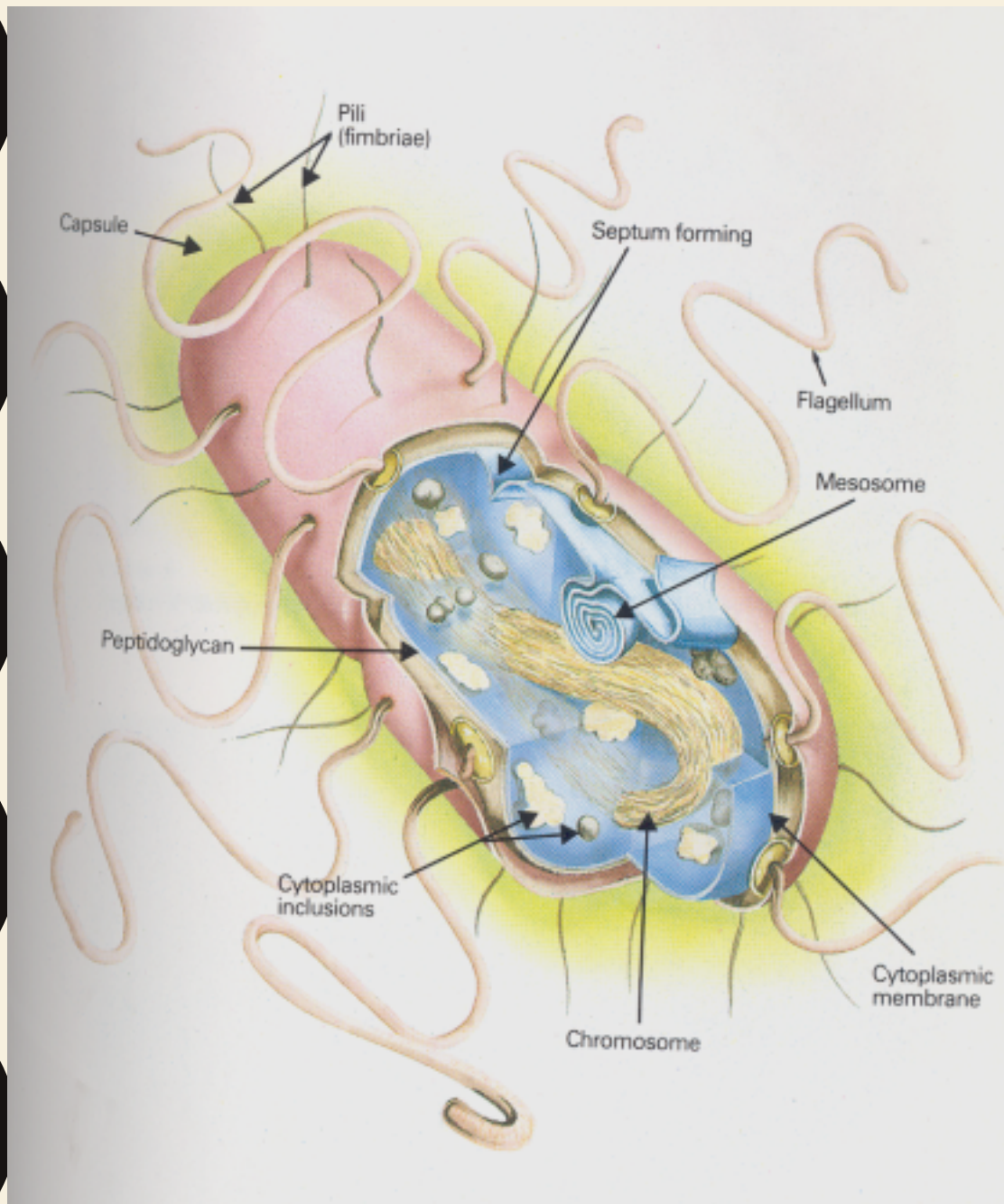


Diagram showing the structure of Gram-negative and Gram-positive bacterial cell walls.



<h1>GRAM STAINING</h1>		
1		
2		
Flow Through Procedure	Wipe bottom of biofilm slide clean	Clean top edges of slide about 2mm
3		
4		
5		
Build up a ridge of petroleum jelly on the top and bottom of a cover slip	Cover slip with petroleum jelly	Biofilm on slide with cover slip
6		
Add crystal violet-wait 30 sec.		
7		
Wash with water		
8		
Add Grams Iodine -wait 1.5 min.		
9		
Decolorize with alcohol		
10		
Wash with water		
11		
Stain with Safranin dye-wait 30 sec.		
12		
Wash with water		
13		
Examine under oil immersion through the cover slip		

External Structures of Bacteria

External protrude from the cell into the environment.:

1-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 (الالتصاق والاستعمار)

2- **Sex pili** : in some bacteria only, responsible for conjugation ((تشارك فيها الجينات))

2-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.

تختلف كثافة الكابسول من خلية إلى أخرى

3-Flagella

- Composed of protein **FLAGELLIN**.
- Helical filaments
- Found in Gram **positive** & Gram **negative** bacteria

Distribution:

- **Peritrichous** (حول كل البكتيريا)
- **Monotrichous** (في طرف واحد)
- **Lophotrichous** (من طرفين)

Structure of Flagella:

Basal Body:

- ❖ a protein arranged as rings on central rod (4 ring in Gram negative, 2 ring in Gram positive).
- ❖ outer pair of rings: only in Gram negative, pushed through outer membrane.
- ❖ inner pair of rings : inserted into peptidoglycan & cytoplasmic membrane.

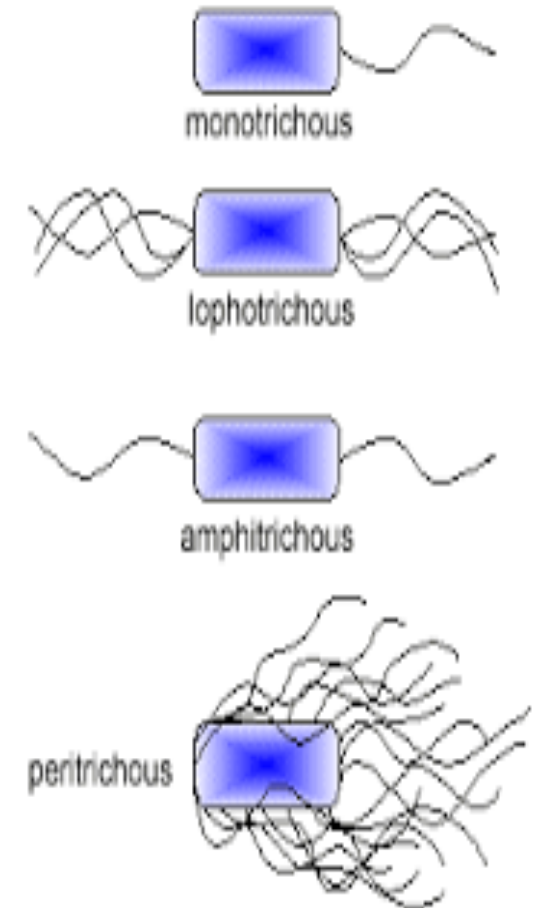
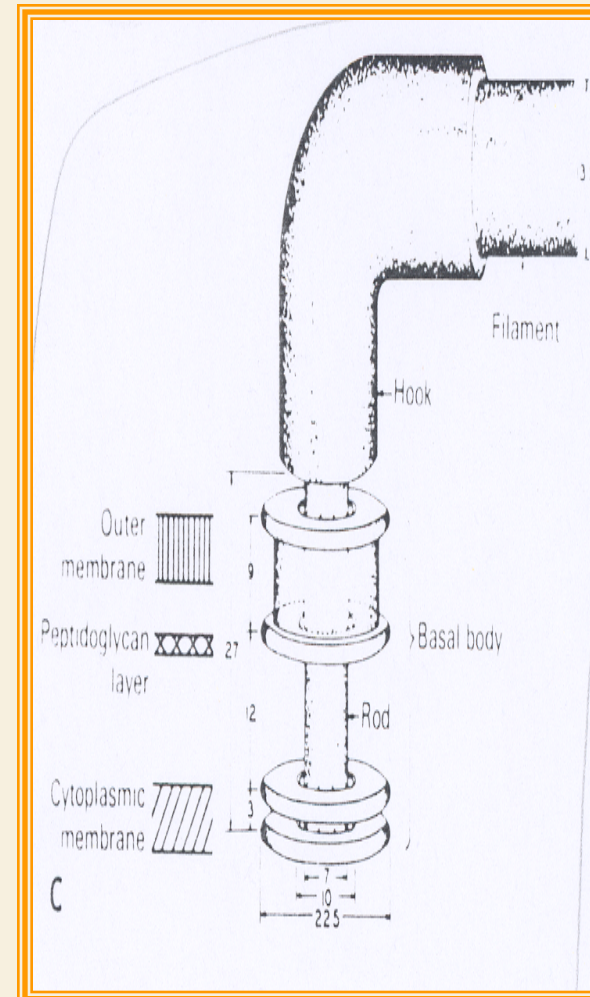
Hook : bent structure -act as joint

Long Filament :Flagellin protein

Function of Flagella : motility & chemotaxis (الاحساس بالخطر والاستشعار كيميائيا)

Chemotaxis :is the movement of an organism in response to a chemical stimulus.

Structure & Distribution of Flagella



CYTOPLASMIC MEMBRANE

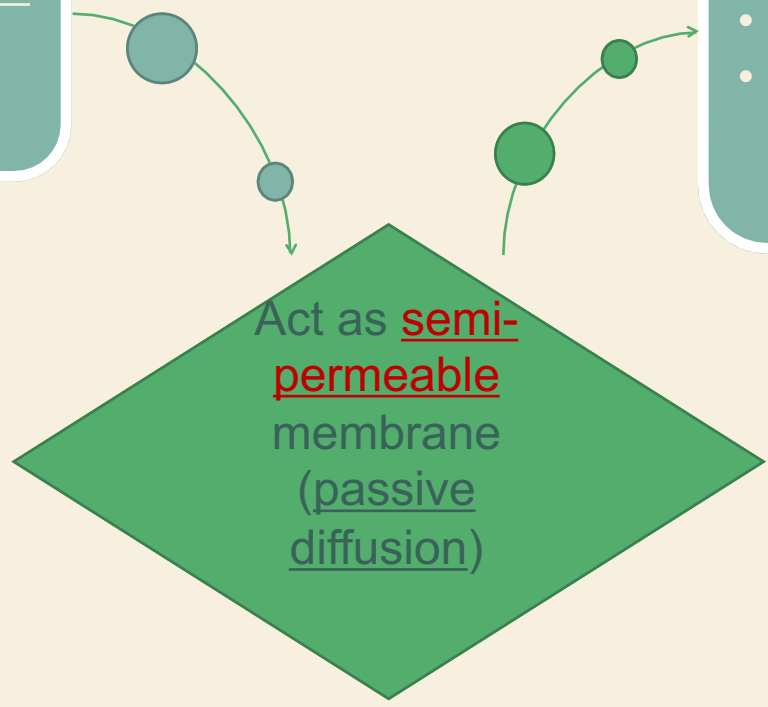
Cytoplasmic membrane (cell membrane):

Double layered structure composed of phospholipid & protein

Site of numerous **enzymes** involved in active transport of

- nutrients &
- various metabolic processes

Act as **semi-permeable** membrane (passive diffusion)



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

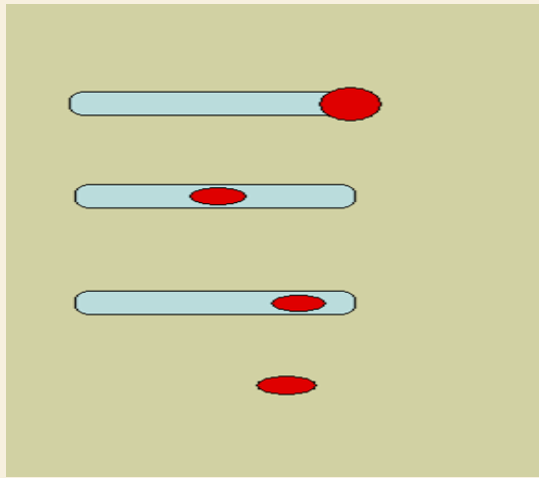
- Small ,dense, **metabolically inactive** , non- reproductive structures produced by **Bacillus & Clostridium**
- Enables the bacteria to survive adverse environmental conditions.
- Contain high concentration of **Calcium** dipicolonate_
- **Resistant to heat**, dissection & disinfectants
- Often remain 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

Spores are described :

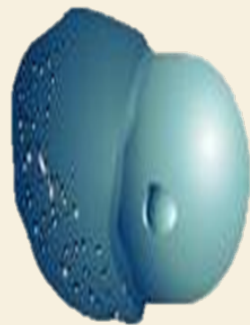


Dormant bacterial spore

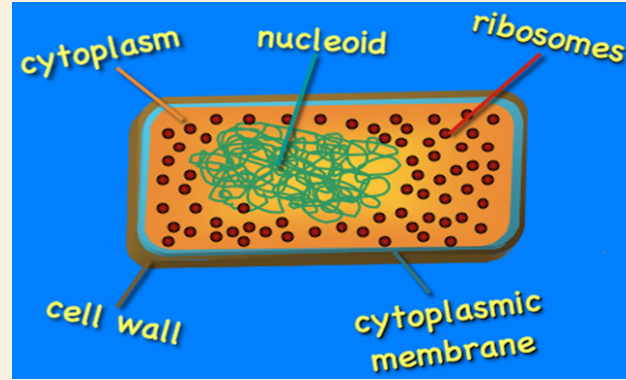
Germinating spore



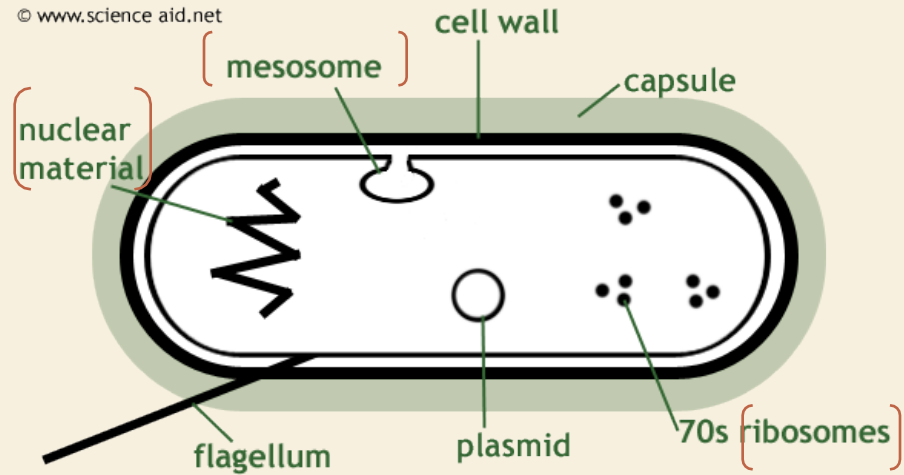
Spore coat



Endospore Formation



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Bacterial Genetics

Definitions:

Genetics

- **Genetics is the study of inheritance and variation.**
- **Genetic information encoded in DNA.**

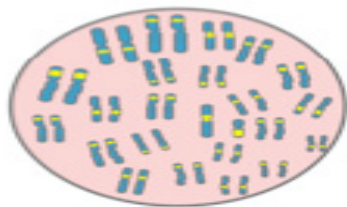
Function of genetic material:

- 1- **Replication** of the genome
- 2- Expression of DNA to **mRNA** then to protein.
Either functional (for metabolism)
Or structural ((الدعامة للخلية))
يعني البروتين المنتج يستهلك حيويًا وللتدعيم: كلام الدكتور *

Genotype:

Is the **complete set** of genetic determinants of an organism.

A **genotype** is the genetic makeup of a person



Phenotype:

Is **expression** of specific genetic Material.

A **phenotype** is the physical manifestation of an inherited trait or disease



Wild type:

Is reference (parent) strain-active.

Mutant: progeny with mutation.

[أي كلام باللون الأخضر هو كلام
الدكاترة]
دائماً متغيرة فبسبب هذا التغير
يطلع منها طفرات

DNA types in the bacteria

Chromosomal

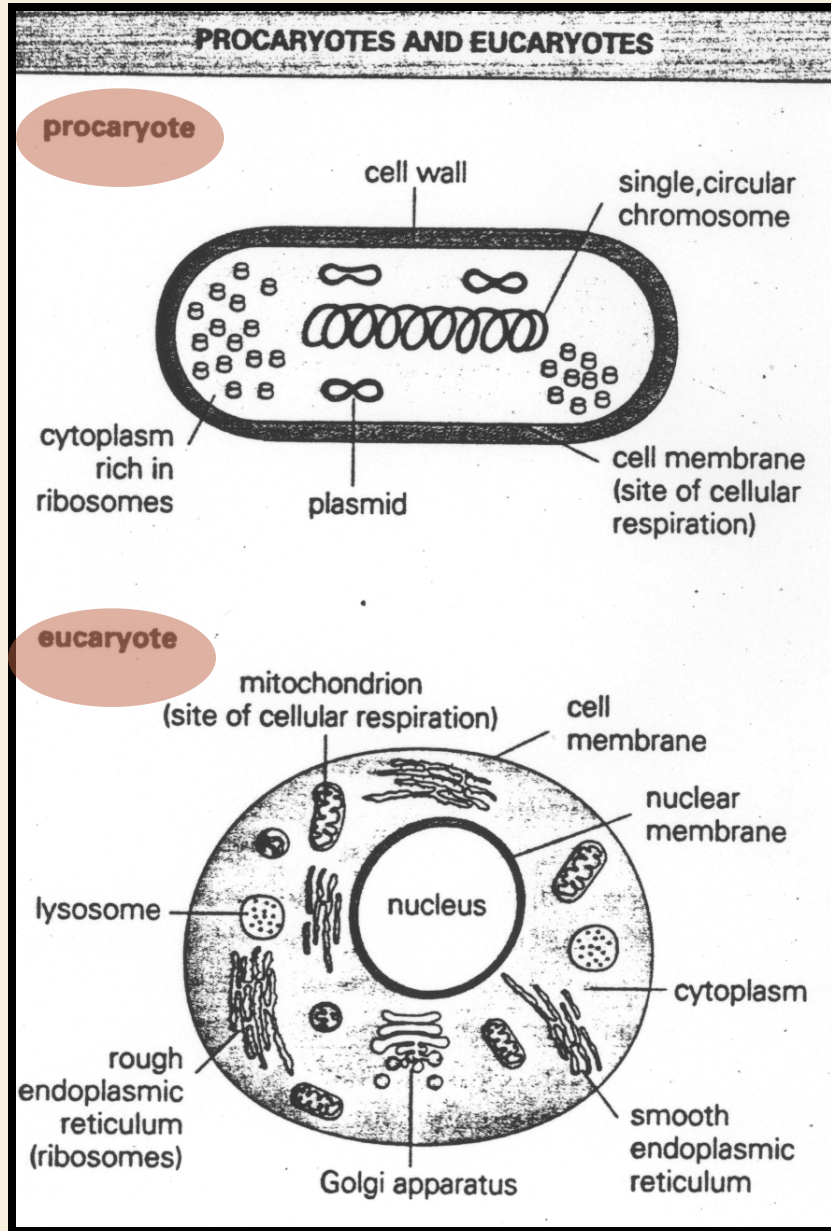
- **Haploid**, circular molecule of **double stranded**- DNA attached to cell membrane.
-
- No nuclear membrane (**prokaryotes**).
- DNA a **double helical** structure, genetic code **in Purine and Pyrimidine** bases of nucleotides that makes DNA strand.
(like human **A T G C**)
 - 3 bases comprise one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

Types of plasmid:
In the next slide

Extra-chromosomal (**Plasmid**).

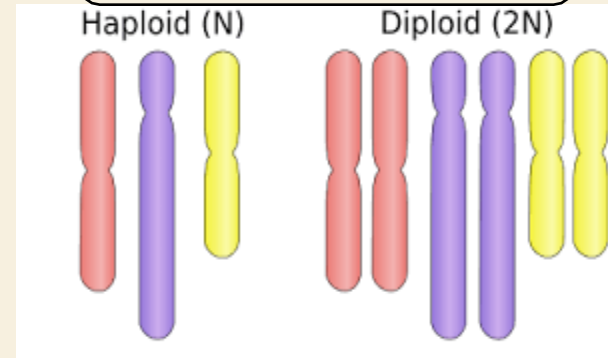
- Extra chromosomal DNA composed of **double stranded-DNA**. (in the cytoplasm)
 - Found in most species of bacteria.
 - Origin? (**un known**)
 - Govern their own replication
- Application : **Genetic exchange, amplify genes**. (مثل الهندسة الوراثية)
- **Transfer by conjugation**
 - Unrelated plasmids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

الفرق بين البكتيريا و الخلية

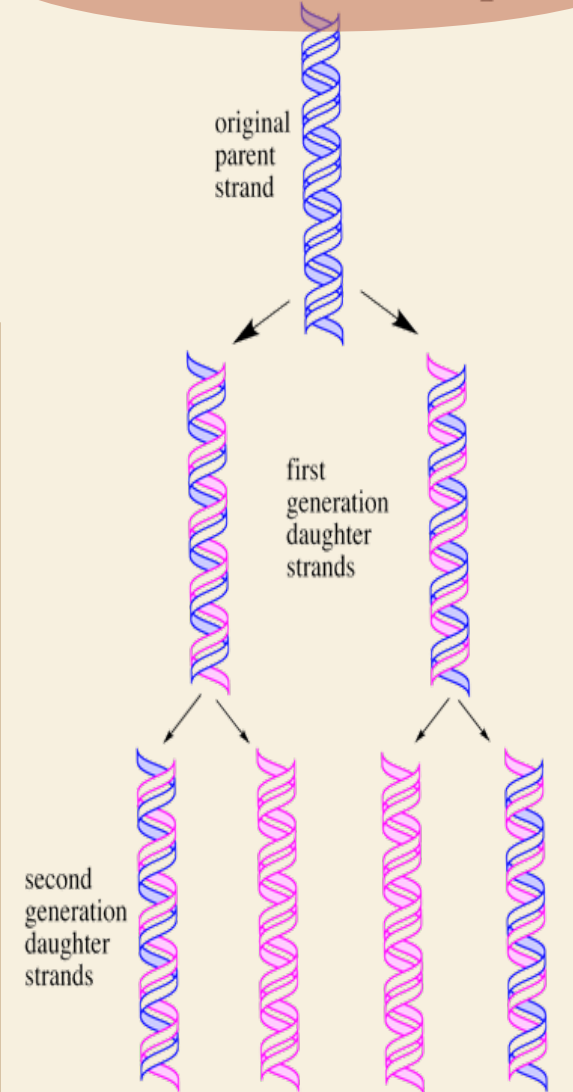
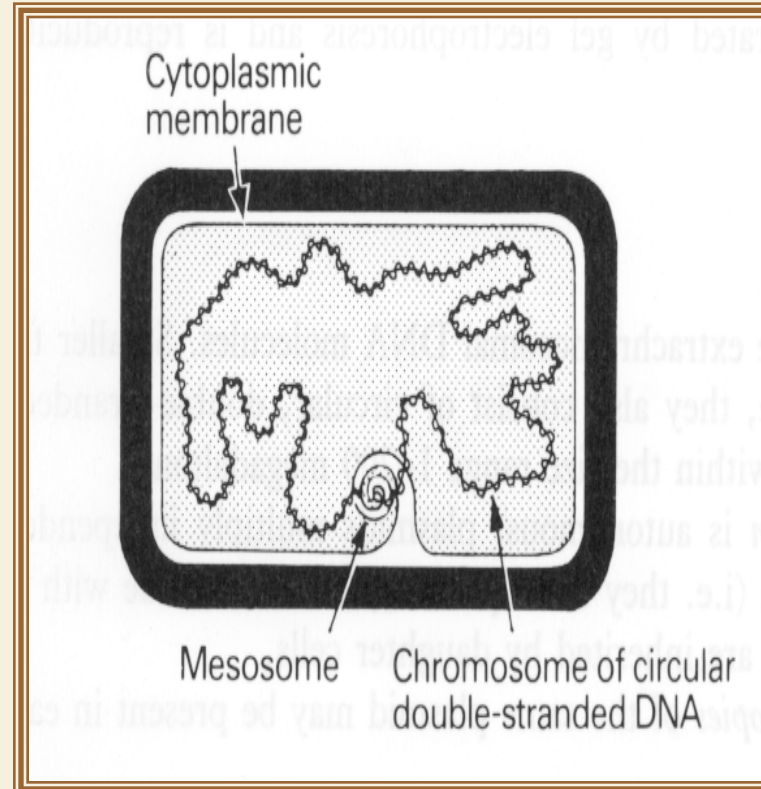


فقط لمعرفة معنى

haploid



Semiconservative Replication



Types of plasmids :

R-plasmids

: genes code for **antibiotic resistance** particularly Gram negative bacteria.

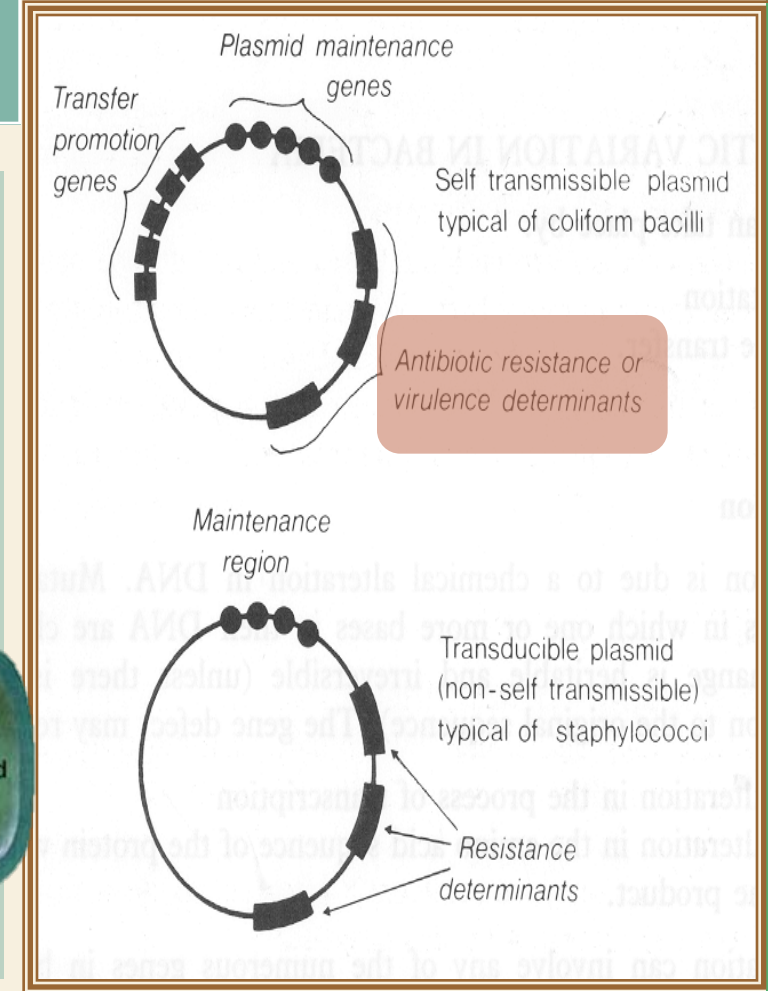
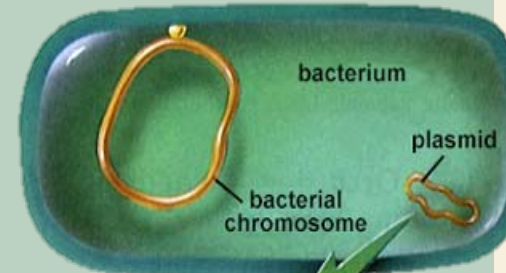
R from the word (Resistance).

Col-plasmids

: in **Enterobacteria**, codes for extracellular toxins.

F-plasmids

:(**fertility**) factor, transfer of chromosome during **mating** .



Genetic variation in bacteria :

Take place by :

Mutations

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

Gene transfer

Coming next

Classification of Mutation:

Depends on biological sequencing:

Resistance mutation

- affect structure of cell protein.
- Main application in **medical** practice
Bacteria become **resistant to antibiotics**

Auxotrophic mutation:

- affect biosynthetic **enzyme** resulting in a nutritional requirement of mutant cell.

Lethal mutation.

- The bacteria die .

Mutation /gene defect leads to alteration in:

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

من الممكن أن تحدث الطفرة في البكتيريا أو فقط في البلازميد.
الطفرة في البلازميد أخطر لأنها من الممكن أن تنتقل لبكتيريا أخرى

Mutation Causes Antimicrobial Resistance

Genetic Mutation Causes Drug Resistance

Non-resistant bacteria exist

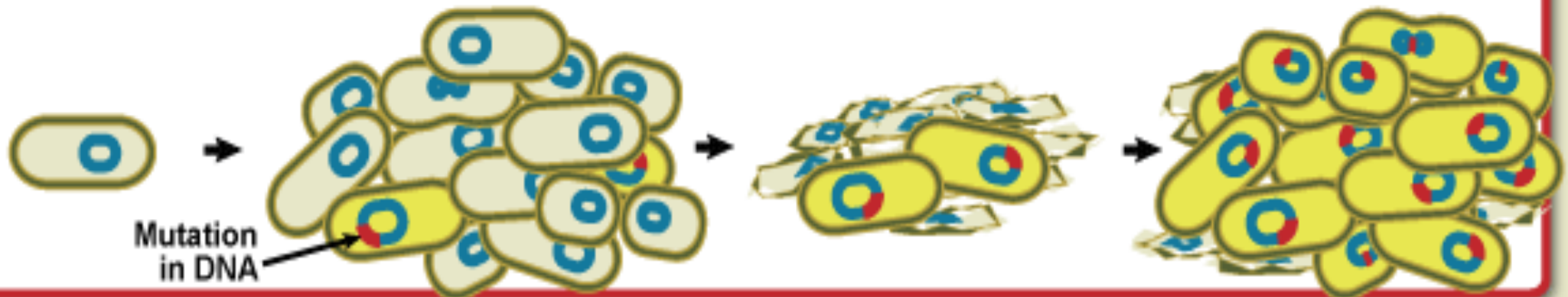
Bacteria multiply by the billions

Some mutations make the bacterium drug resistant

Drug resistant bacteria multiply and thrive.

A few of these bacteria will mutate.

In the presence of drugs, only drug resistant bacteria survive.



Gene Transfer Among Bacteria

Transformation

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

Common in *Haemophilus influenzae* & *Streptococcus pneumoniae*.

Bacteria become resistant to Ampicillin.

Transduction

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

Example:

Beta – Lactamase production in *Staphylococcus aureus* : **Bacteria becomes resistant to penicillin.**

Toxin production in *Corynebacterium diphtheriae*.

Conjugation

Major way bacteria acquire additional genes.

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

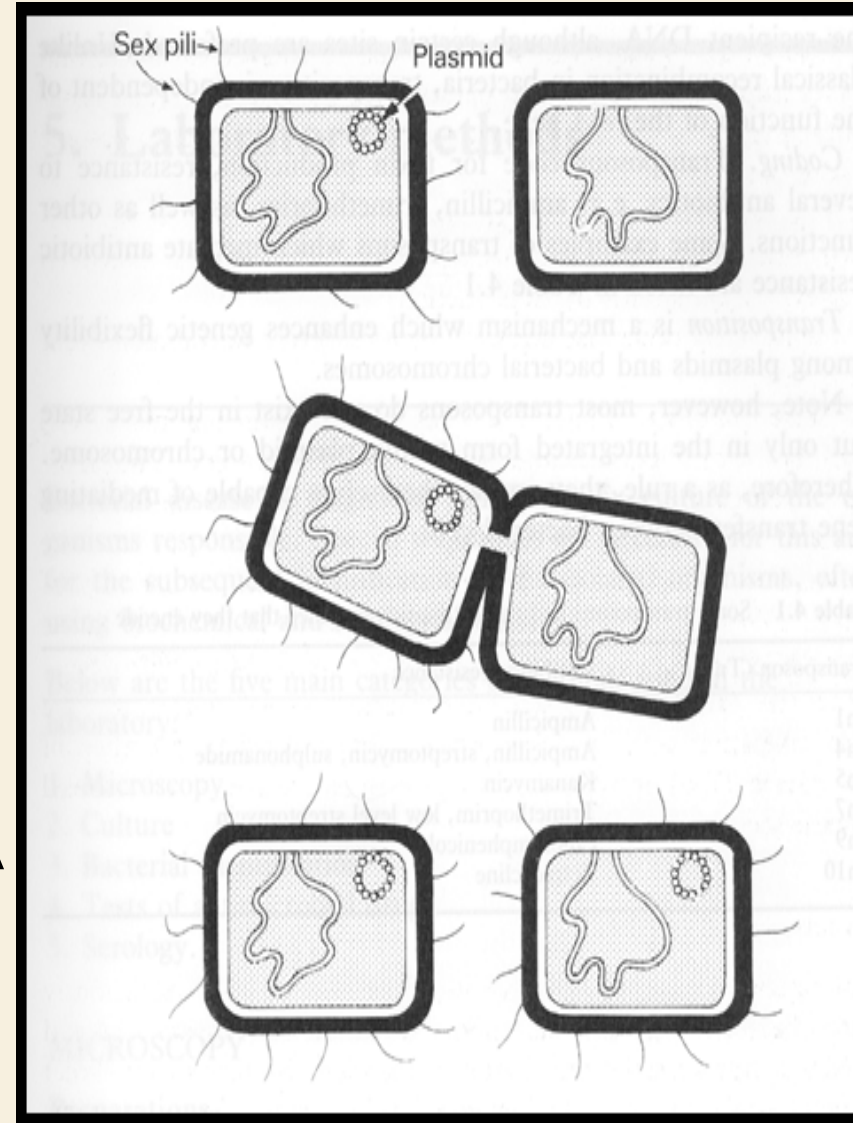
Conjugation is the common way of transfer of genes resistance to antibiotics among bacteria in hospitals.

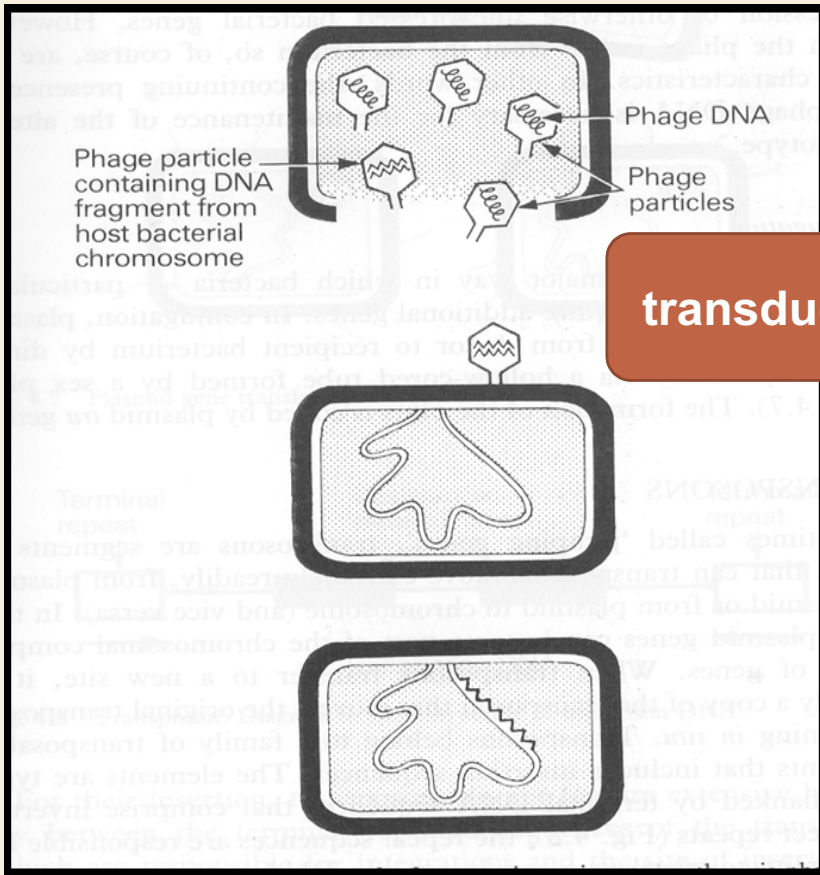
CONT...

conjugation

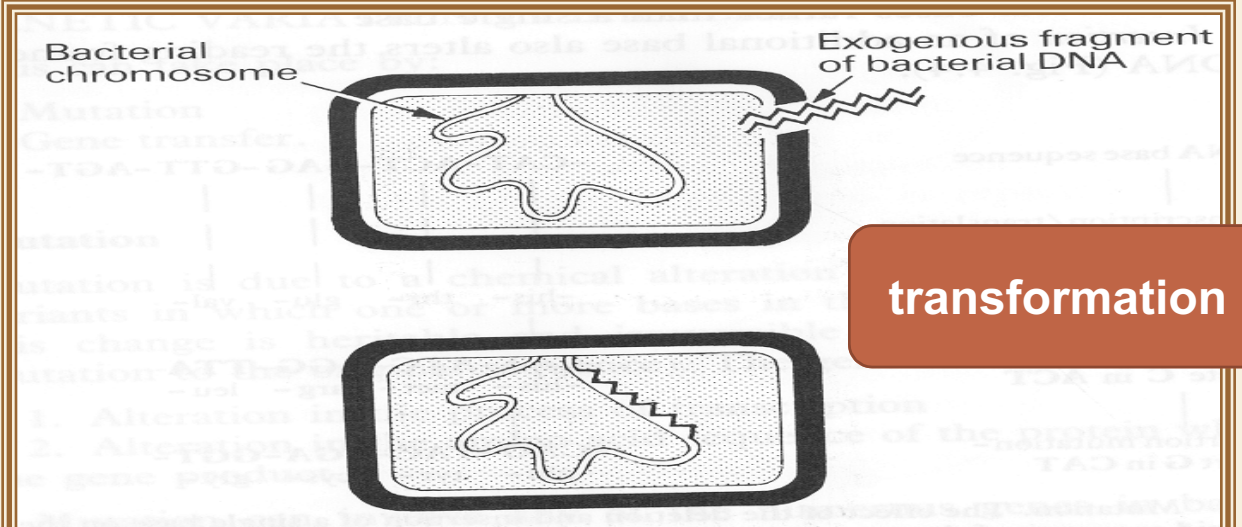
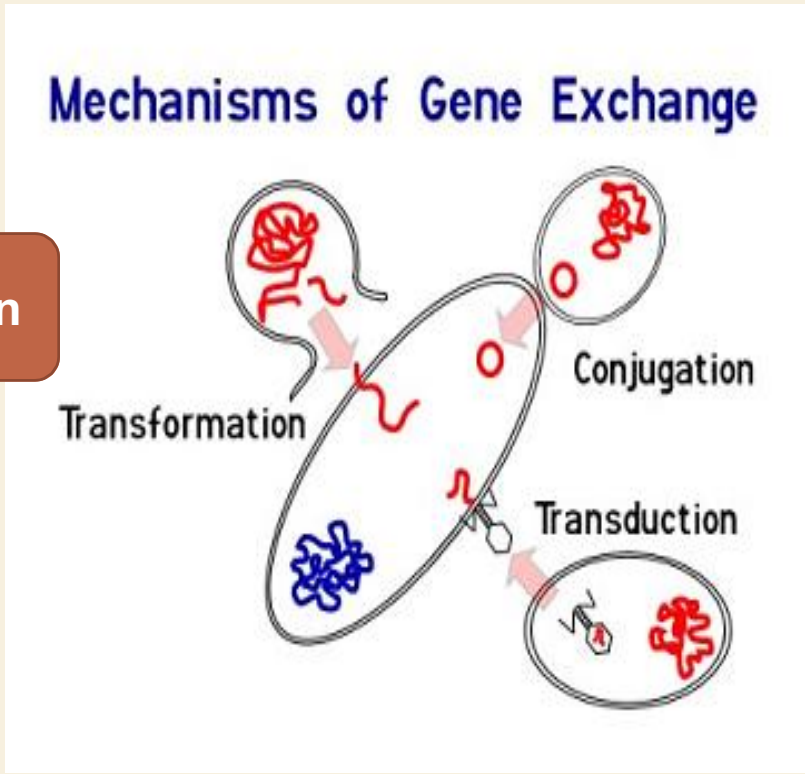
Mediated by plasmid called **F factor (fertility)**.

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.





transduction



transformation

GENE TRANSFER AMONG BACTERIA

<u>Mechanisms:</u>	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	<ul style="list-style-type: none"> • Major way bacteria acquire additional genes. • Plasmid mediated • Cell contact required and genes reside on plasmid resident within donor cells transfer to recipient cell (mating).
Example:	<ul style="list-style-type: none"> • Common in <i>Haemophilus influenzae</i> & <i>Streptococcus pneumoniae</i>. Bacteria become resistant to Ampicillin. 	<ul style="list-style-type: none"> • Beta – Lactamase production in <i>Staphylococcus aureus</i> : Bacteria becomes resistant to penicillin. • Toxin production in <i>Corynebacterium diphtheriae</i>. 	<p><u>Conjugation is the common way of transfer of genes resistance to antibiotics among bacteria in hospitals.</u></p>

GENETIC RECOMBINATION

After gene transfer, there are three possible fates:

1-Exogenous DNA degraded by nuclease.

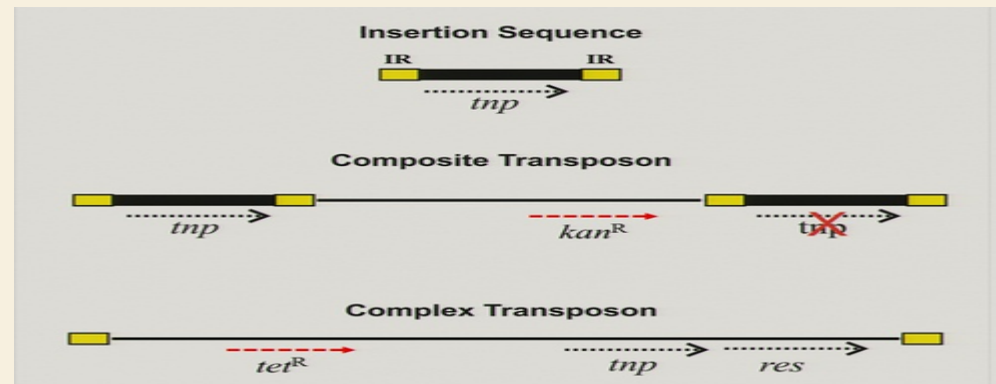
2-Stabilized by circulization and become plasmid.

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

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.
- Types: 1- Transposons .
2- Insertion sequence

<https://www.onlineexambuilder.com/bacteria-l-structure-function-bacterial-genetics/exam-35905>



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