Mavzu:
Bakteriya hujayrasining struktura asosi, bakteriya o‘lchamlari va morfologiyasi

ULTRASTRUCTURE OF BACTERIAL CELL

As bacterial cells are very **minute-kichkina**, they are studied under electron microscope in which it *reveals-kashf* etilganda various-turli **structures:**

1.Some of these are external to the cell wall

2.while other are **internal to the cell wall**.

The brief-qisqacha descriptions-tasvir of the readily-osonlik bilan evident-ma’lum structures of bacteria is as follows-quyidagicha :

Structure external to cell wall.

(a) Flagella

(b) Pili (Fimbriae)

(c) Capsules

(d) Sheaths

(e) Prostheceae and stalks

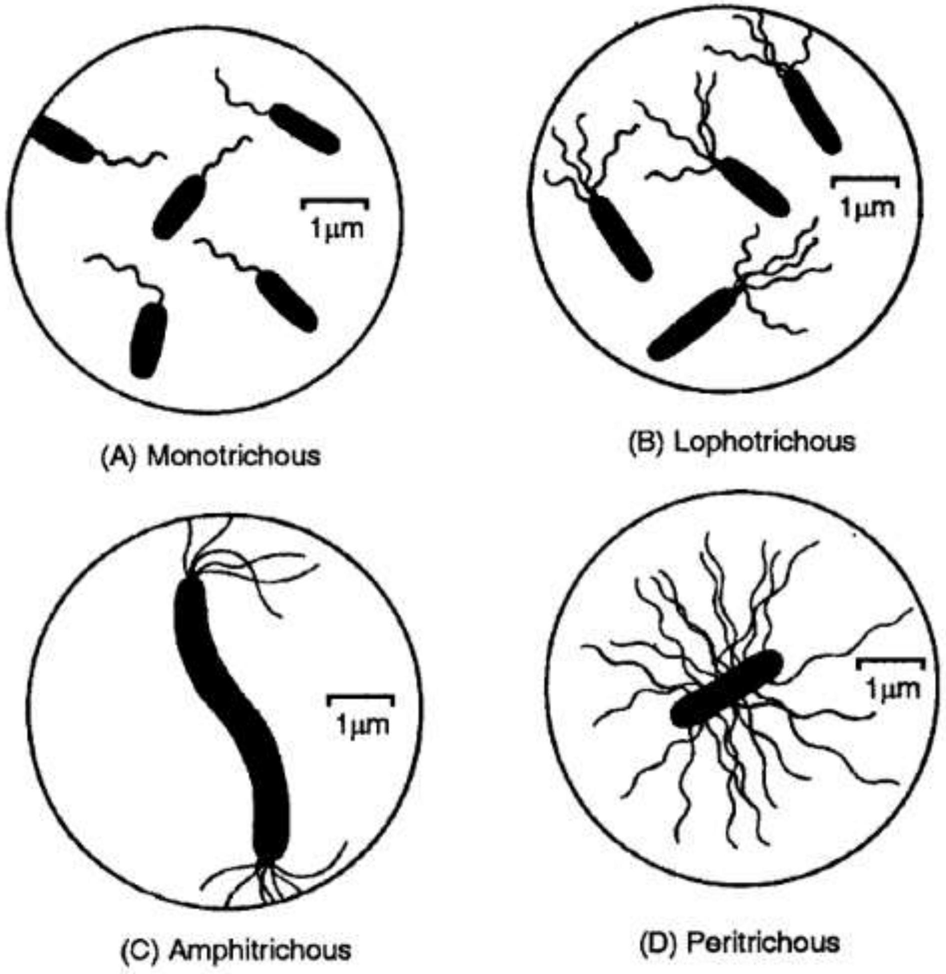
(f) Cell wall

(a) Flagella

The main function of flagellum is to provide motility to the bacterial cell.

Bacteria can be **motile** or non **motile**. Chemically **they are made up of protein** with a molecular weight of about 40,000. The protein of the filament is known as **flagellin-oqsil nomi**.

The location of flagella varies in **various bacteria**. **The bacteria which lack** flagella are **referred-bildiradi, anglatadi as atrichous**. *Diptheria bacilli* and many *cocci* viz-ya'niy. *Lactobacillus* and *Pasturella*. **The number** and **position** of the **attachments-joylashgan** of the flagella **on the bacterial wall** **vary-farq qilmoq** according **to the species**. Therefore bacteria can be **divided** into **following types** :



Various arrangement of bacterial flagella.

Generally a single flagellum is **ten times long** as **compared** to their **bacterial cell**

These flagellum are generally **made up** of **subunits-subirlik** of flagellin protein.

The molecular weight of these subunit is **40,000**) dalton and **40A°** **in diameter**.

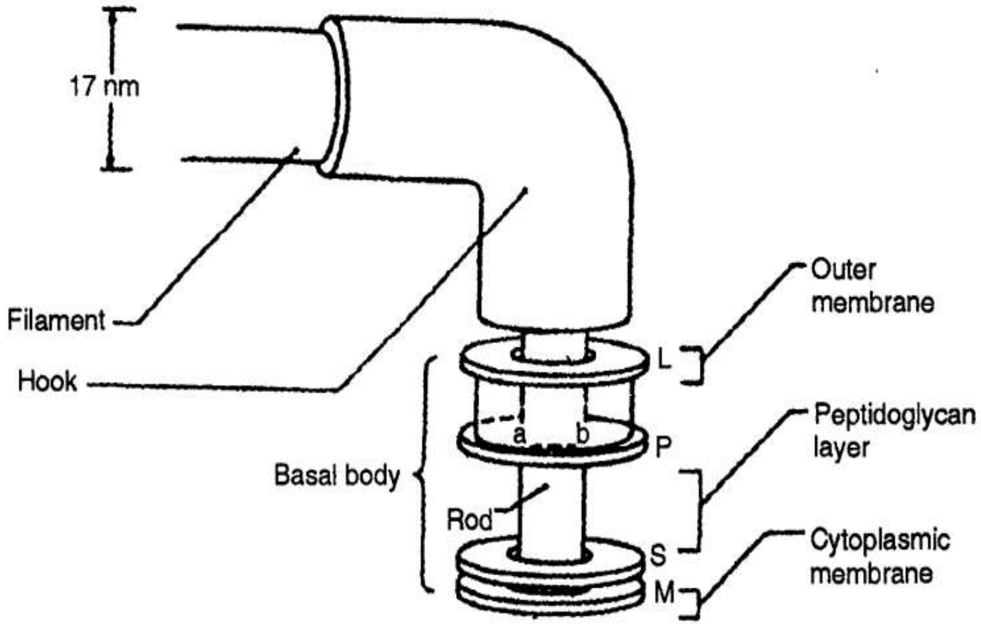
This flagellin protein is **synthesized** inside the **bacterial cytoplasm** and are **transferred** to the terminal distal part of the flagellum, **thus-shu asosida** the growth of flagellum is from apical part inspite of its basal part.

About 12 genes are found **responsible-javobgar** for the synthesis of various **parts of flagellum**. **Each bacterial flagellum** is **structurally differentiated into three parts:**

(1) basal body

(2) hook-ilgak

(3) main filament or shaft-stvol



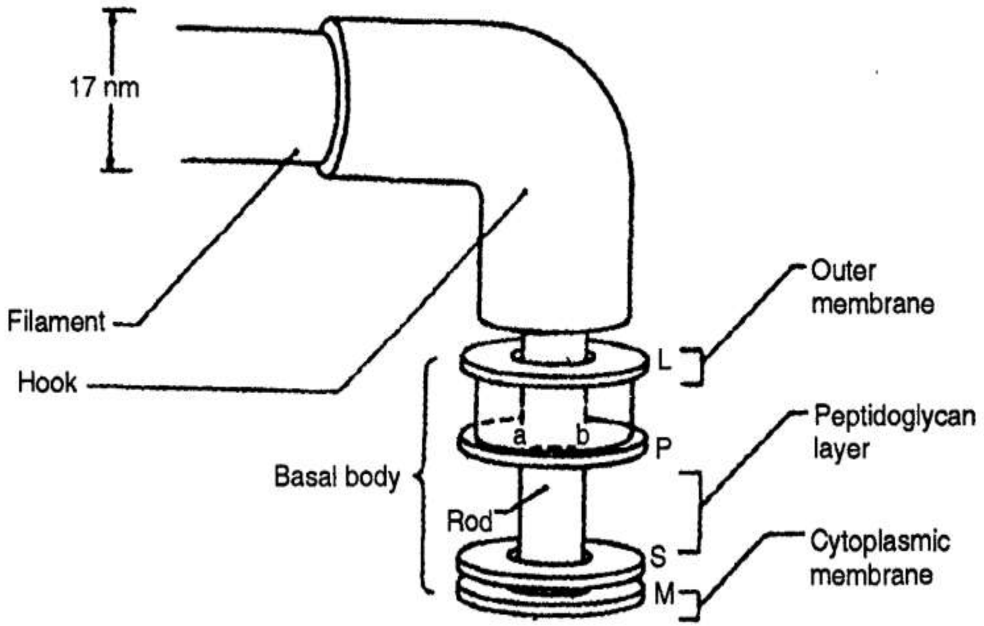
Structure of flagellum of gram -ve bacterium

Basal Body:

It is a small rod-chigal like structure which is attached deep in the cytoplasm of the bacterial cell. **This cytoplasm provide energy to this flagellum**.

Bacterium it possesses **two sets** of rings (i) a proximal set (ii) a distal set. Each set consist of two **pairs of rings**. **Outer pair is attached** to the **cell wall** while **inner pair** is **attached to the cell membrane**

The main **function of basal body** is **to synthesize the polymers of flagellum,** regulation of **flagellar movement**.



Structure of flagellum of gram -ve bacterium

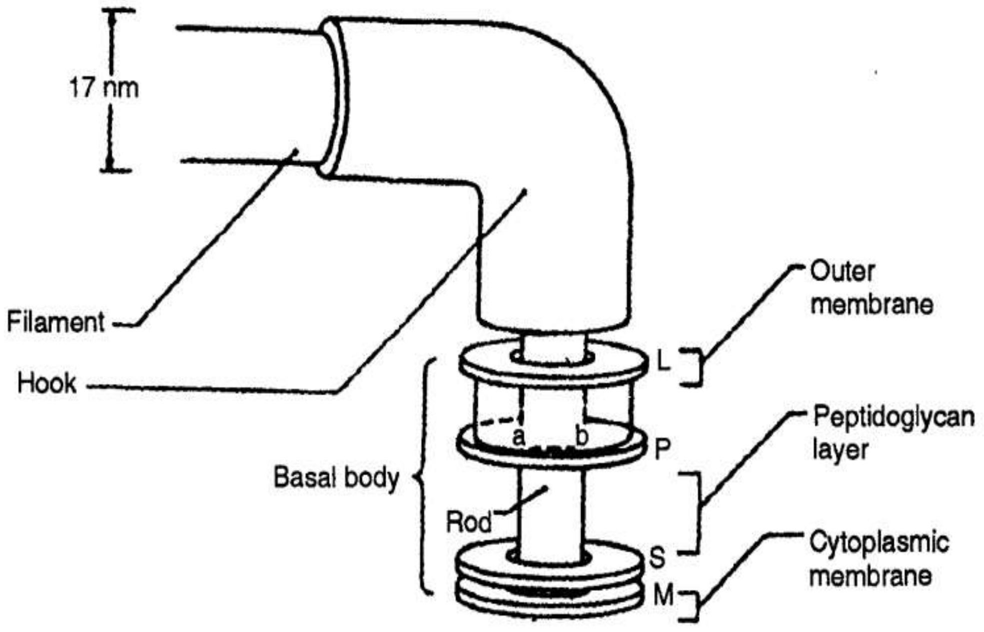
Hook-ilgak

Hook **connects** the basal body and main filament or **shaft-o'q**. It originates-**kelib chiqmoq** from **cell wall** and the **length** of hook of **gram negative** bacterium is shorter than of **gram positive** bacterium.

The main features of hook are:

They provide specific shape to the flagellum.

Each hook has specific antigenic property-xususiyat in each bacterium.



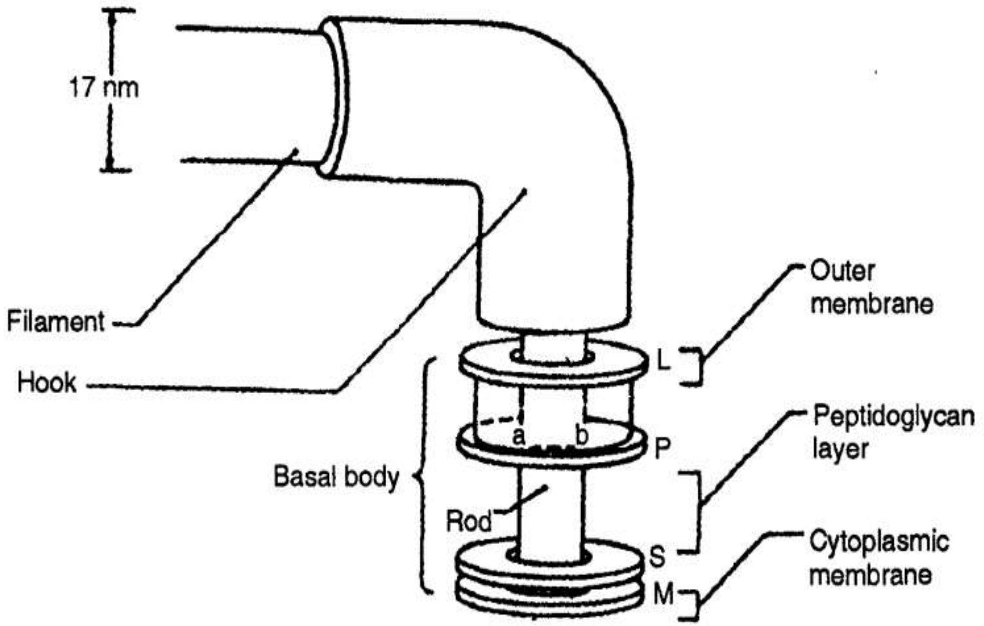
Structure of flagellum of gram -ve bacterium

Filament or Shaft

This is a tubular structure **attached to the hook**. It is **made up of globular protein** subunits.

The amino acid involve in the synthesis of proteins are histidine, cystine and tryptophane. These protein subunits are arranged helically and form cylindrical fibrils.

The protein is called flagellin. The bacterial flagellum is made up of single thin fibril



Structure of flagellum of gram -ve bacterium

PILI OR FIMBRAE

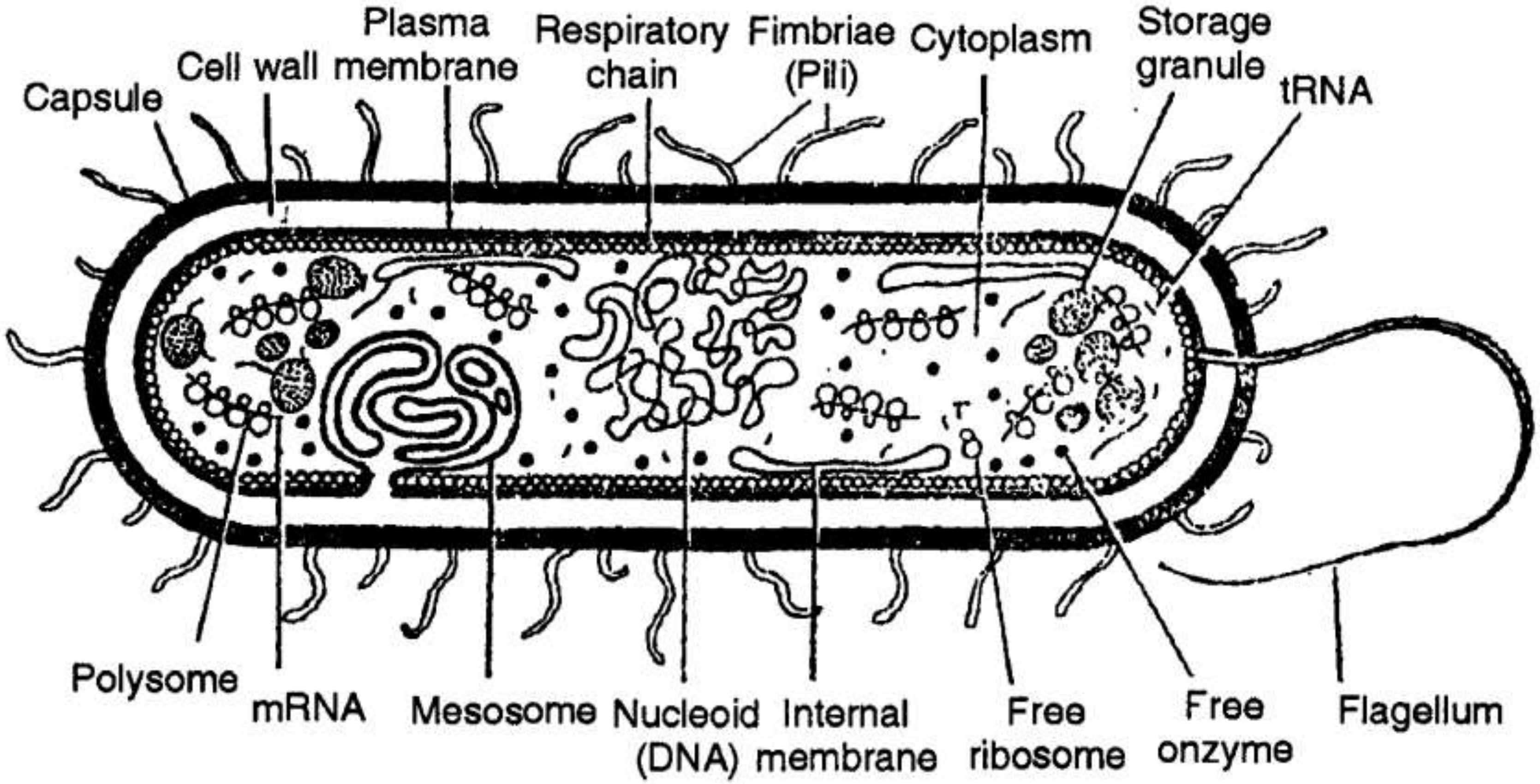
These are **hair like** appendages-qo‘shimcha present on the **surface of most** of the gram negative bacteria (Enterobacteriaceae, Pseudomondaceae and Caulobacter).

They are smaller than flagella, have **no role** in the **motility of bacteria**.

A single bacterial cells bears about 100-500 pili which are arranged **peritrichously**.

There **origin** is from **cytoplasm** and penetrate through the **peptidoglycan layers** of the cell wall.

Chemically they are composed of 100% protein **named fimbrilin** with a molecular weight of about 16,000. Fimbrilin consist of about 163 amino acids.



Generalized diagram of a bacterium

Following two types of pili are found in bacteria viz.

(a) Somatic pili

(b) Jinsiy-pili or conjugate pili

(a) Somatic Pili : Each bacterial cell **bears-mavjud** about 100 somatic pili whose **main function** is to **help** the bacterium for **attachment to a substratum.**

(b) Jinsiy- Pili or Conjugate Pili : They are also known as **F pili** and are **controlled** by **jinsiy-factors**. There number **ranges-qamrab olmoq** from 1-10 in **male** or **donor** bacterium, but in some bacterium it is **found in both** viz.

Male donor (+ factors) or female receptor/ receiver (- factor). At the time of conjugation the jinsiy-pili of male donor recognize the receptor protein on the surface of female or recipient and get **attached with the help ot conjugation tube**. **The DNA** from the donor to recipient is **transferred** through this conjugation tube.

There are **two types** of jinsiy-pili in E.coli. They are **F**. pili and I.pili.

In certain-ayrim pathogenic bacteria these pili help the bacteria in the attachment of pathogenic bacterial cell to the **host cells**. There are generally four types of pili classified on the basis of their attachment ability to the host cell :

Functions of Pili

(i) **They help** the bacteria to attach themselves to the natural substrate or to **other organism** due to its **adhesive-yopishqoq** ***properties-xususiyat***.

(ii) They **bear-mavjud** antigenic ***properties-xususiyat.***

(iii) Jinsiy-pili are **helpful** in chromosome transfer during conjugation by acting as conjugation tube.

(iv) They act as **bacteriophage receptor.**

Capsules

Some bacterial cells are surrounded by a **viscous-yopishqoq substance-modda** forming a covering **layer-qatlam** or **envelope-o‘rab olgan** around the cell wall **called capsule.** Electron microscopic study has **revealed-kashf etilgan** that capsule consist of a **mesh-to‘r** or **network-tarmoq** of fine ***strands-tizim, tola***. This **capsule only helps** in **disease-kasallik** causing ability of a few types of bacteria.

This capsule is divided into two groups:

(a) Macrocapsule: It is thick and can be seen under light microscope.

(b) Microcapsule: It can't be seen under light microscope but can be **demonstrated immunologically.**

Chemically: the capsules are made up of **di or polysaccharide or polypeptide**. The polysaccharide may be **homopolysaccharide** (composed of single kind of sugar) e.g. Streptococcus mutans ot it may be **heteropolysaccharide** (composed of several kind of sugars) e.g. Klebsiella pneumoniae.

Functions

(i) They provide-ta’minlaydi **protection-himoyalab** against temporary drying by binding water molecules.

(ii) They may be **antiphagocytic** i.e. they inhibit the engulfment of pathogenic bacteria by W.B.C. and contribute to invasive ability.

Sheaths

Some species of bacteria of freshwater and marine environment form chains or trichomes which are enclosed by a *hollow-teshikli tube-quvur* called sheath. Sheaths may be sometimes impregnated with ferric or manganese hydroxides which strengthen them.

Chuchuk suv va dengiz muhitidagi bakteriyalarning ayrim turlari zanjirlar yoki trichomalarni hosil qiladi, **ular g'ilof deb ataladigan ichi bo'sh naycha bilan o'ralgan.**

Prosthecеae and Stalks

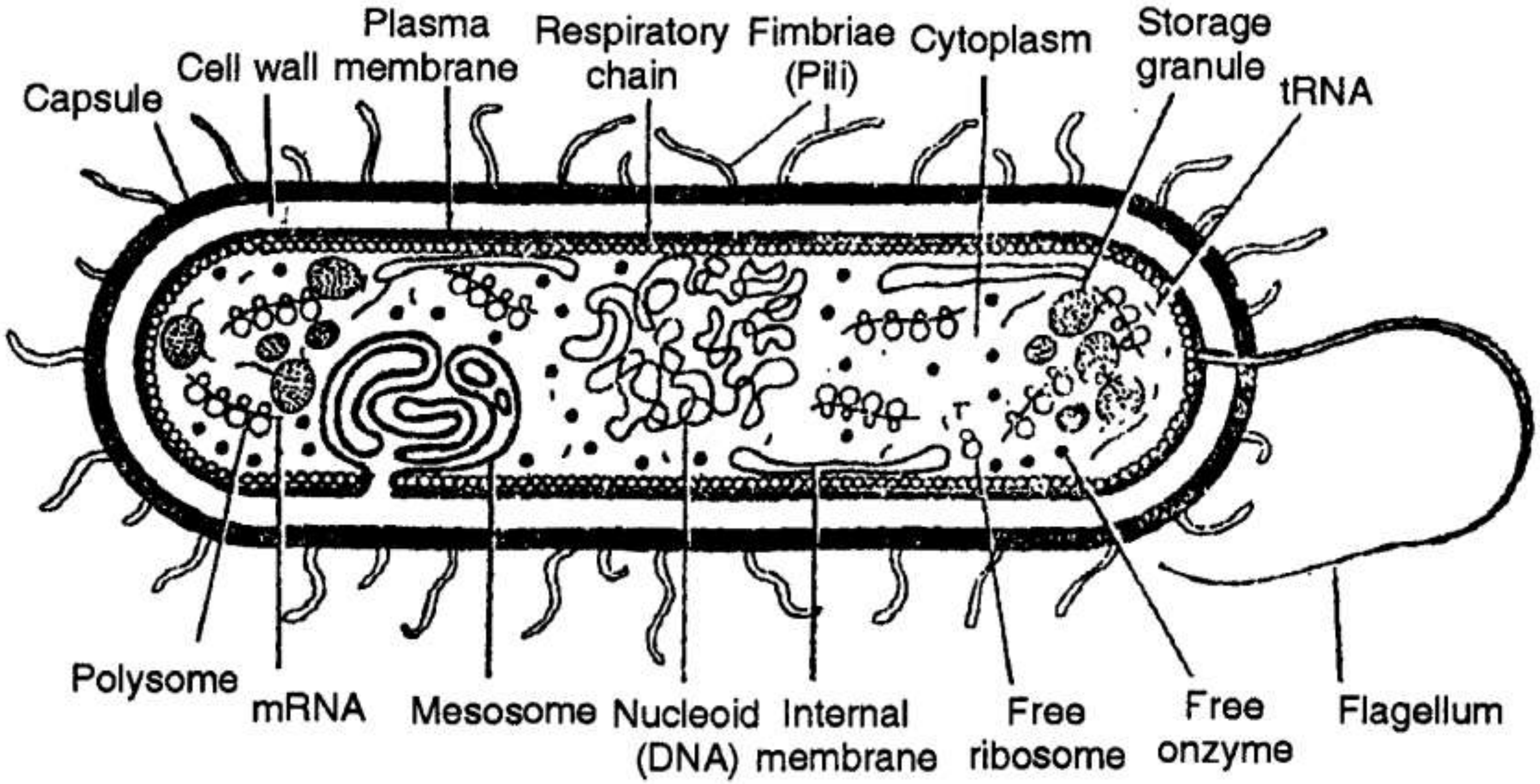
These are semirigid extensions of cell wall and cytoplasmic membrane. They are characteristic of a number of aerobic bacteria from freshwater and marine environment. These prosthecae may be single (ex. Caulobacter) or several (Ancalomicrobrillm) The main function of prostheceae is that they increase the surface area of the cells for nutrient absorption in the dilute environment. Stalk are non living ribbon like or tubular appendages that are excreted by the cell. The stalk aid in attachment of the cells to surfaces e.g. Plallctomyces.

Bu hujayra devori va sitoplazmatik membrananing semirigid kengaytmalari. Ular chuchuk suv va dengiz muhitidan bir qator aerob bakteriyalarga xosdir. Ushbu protezlar bitta bo'lishi mumkin (masalan. Caulobacter) yoki bir nechta (Ancalomicrobrillm) prostheceae ning asosiy vazifasi shundaki, ular suyultirilgan muhitda ozuqa moddalarini singdirish uchun hujayralar sirtini ko'paytiradi. Sopi bu hujayra tomonidan chiqariladigan tirik bo'lmagan lenta yoki quvurli qo'shimchalar. Sopi hujayralarni sirtlarga biriktirishda yordam beradi, masalan.

THE CELL WALL

Below these external structures viz. capsules, sheaths, flagella and **above to the** cytoplasmic membrane is the cell wall. This is a very **rigid-qattiq** structure and provide **definite-muayyan shape** to **the cell**. Since most of the bacteria lives in hypotonic environment, this cell wall **prevent-oldini olmoq** the cell from **expanding-kengaytirishda** and **eventually-oxirida bursting-yorilishda** because of uptake of water. The cell wall is **resistant-mahkam** to extremely high pressure.

It may account for as such **10-40%** of the dry weight of bacterial cell. Bacterial cell walls are usually essential for the **growth and division** of bacteria



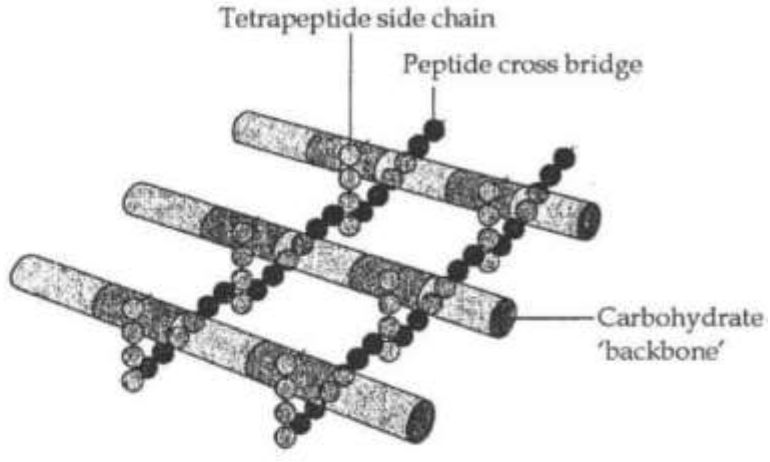
Generalized diagram of a bacterium

STRUCTURE AND CHEMICAL COMPOSITION

The most important constituent of the cell wall of eubacteria is ***peptidoglycan*** (sometimes ***called murein***) which is an insoluble, porous, cross-linked polymer of enormous strength and rigidity.

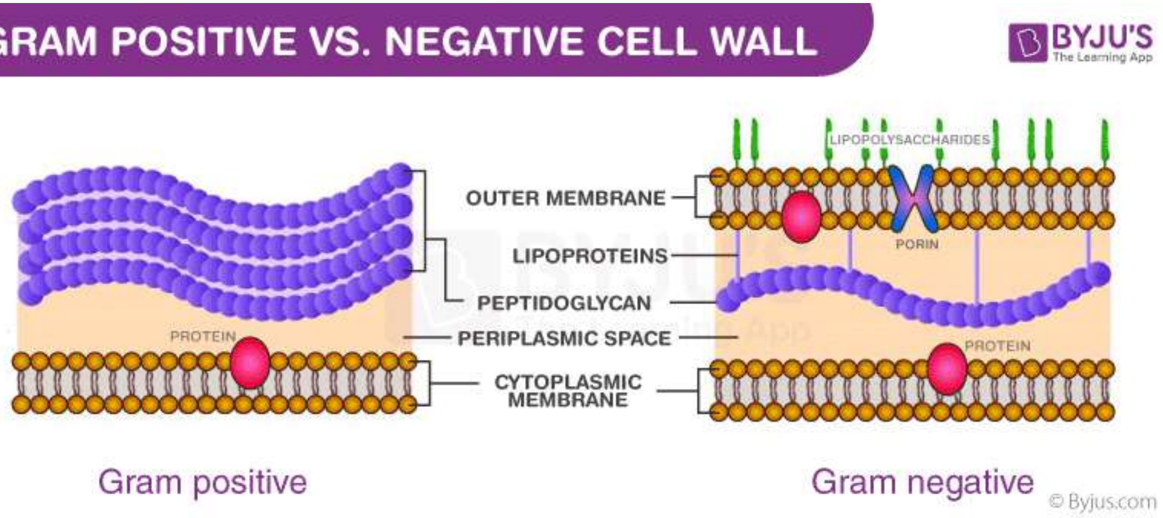
This peptidoglycan is ***only found in prokaryotes***. It is basically a polymer of N-acetyl glucosamine (NAG), N acetylmuramic acid (NAM), and 4 amino acids (L-alanine, D-alanine, D-glutamate and a diamino acids).

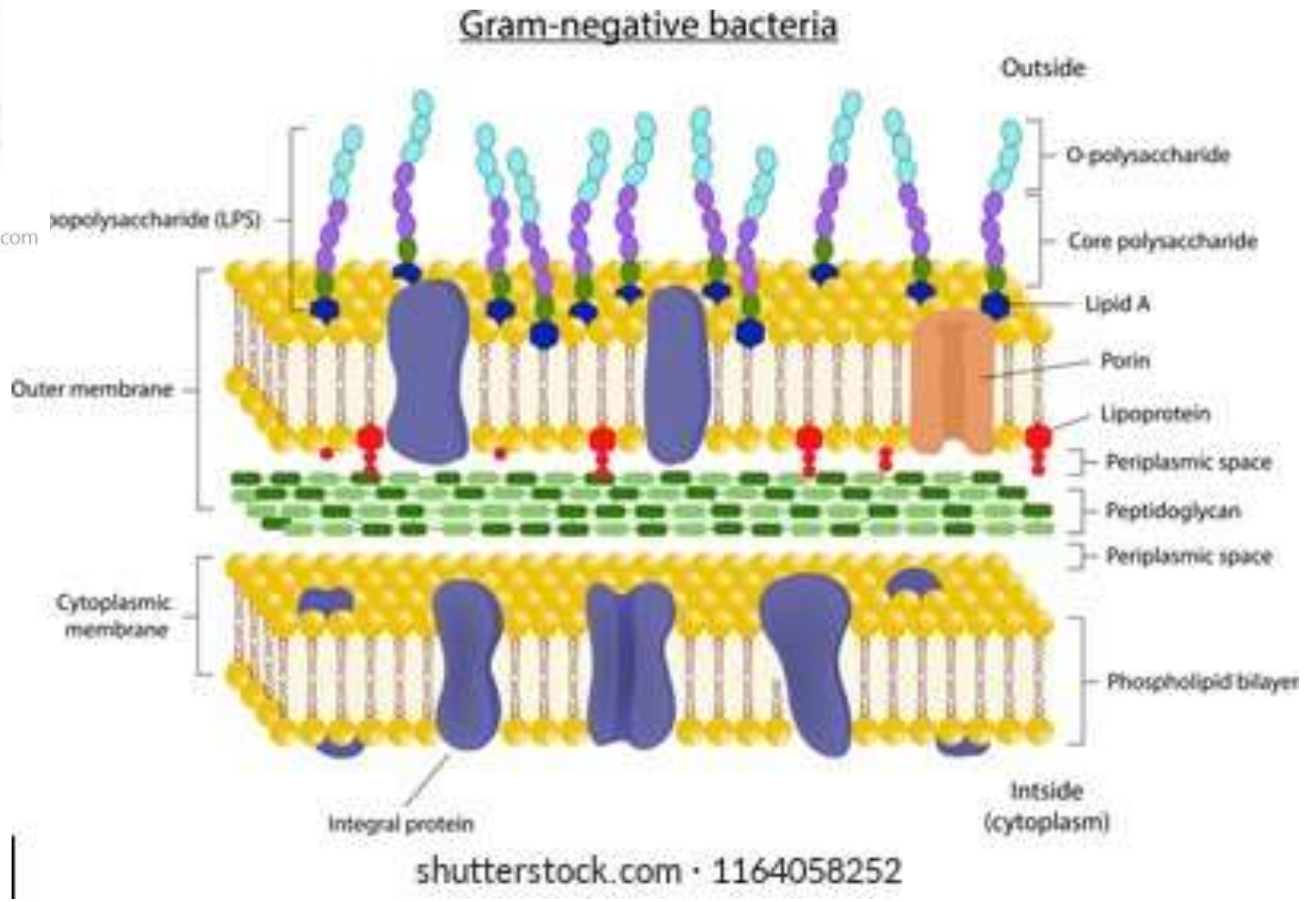
The tetrapeptide of one peptidoglycan layer is cross linked with the other peptidoglycan layer and as a result a ***strong framework is formed around the cell*** and impart great rigidity to the total structure. ***Some antibiotics*** viz. penicillin inhibit the synthesis of this framework thus the cell wall synthesis is stopped.



General structure of peptidoglycan

GRAM POSITIVE VS. NEGATIVE CELL WALL





Walls of Gram +ve and Gram -ve Bacteria

Gram + ve bacteria have a much greater **amount of peptidoglycan** in their cell walls than do **gram - ve bacteria.**

The cell wall of these bacteria consist of about 40-80% of peptidoglycan of the dry weight of cell wall. This peptidoglycan is of about 40 or more layers in gram + ve bacteria. The cell wall measures about 30-80 nm in thickness. Teichoic acid or acidic polysaccharide are mainly present in gram positive bacteria and are found associated with peptidoglycan by a single terminal covalent bond.

The cell wall measures about 30-80 nm in thickness. Teichoic acid or acidic polysaccharide are mainly present in gram positive bacteria and are found associated with peptidoglycan by a single terminal covalent bond. ***Teichoic acid is a negatively charged*** substituted polysaccharide polymer ***made up of ribitol and glycerol*** residues joined ***through diphosphoester linkages***. **(Teichoic acid was discovered by Baddiley (1933).**

Cell Wall of Gram Negative Bacteria

The wall of gram - ve bacteria are more complex than those of gram + ve bacteria.

The envelop of this kind of bacteria is made up of two unit membranes and are separated by 100Ao space known as periplasmic ***region and contains a peptidoglycan layer.*** The outermost membrane is known as cell wall while the inner one is referred as cytoplasmic membrane. Peptidoglycan is only about 5-10% of the dry weight of cell wall.

Gram (+) vs Gram (-)

Structure Internal to Cell Wall

Cytoplasmic Membrane:

Immediate below the cell wall is cytoplasmic membrane which is **similar** in both gram + ve and gram -ve bacteria.

It is about 75 nm thick bilayered membrane and is composed primarily of phospholipids ***(about 20-30%)*** and ***proteins (about 60-70%).*** The phospholipid form a bilayer in which most of the proteins are **tenaciously-mustahkam** held (integral proteins). These protein only can be removed by destruction of the membrane or by the **treatment-munosabat** with **detergents-tozalash.** Other proteins are loosely **attached (peripheral proteins)** and can be removed by mild treatment such as ***osmotic shock.***

Each phospholipids molecule of the bilayer **has both hydrophilic** head facing outwards and a **hydrophobic tail** facing towards each other. The lipid matrix of the membrane has fluidity. This type of structure of plasma membrane is known as **fluid mosaic model.**

The cytoplasmic membrane **act-bajaradi** as a **hydrophobic barrier** for the **penetration-ichiga kirishi** of most water soluble molecules. **However specific proteins** in the membrane facilitate the passage of small molecules (nutrients and waste products) **across-kiradi** the membrane. The cytoplasmic membrane also contains various enzymes involved in respiratory metabolism and in synthesis of capsular and cell wall components.

INTRACELLULAR MEMBRANE SYSTEM

Mesosome: Bacterial cell do not contain membrane bound organelles (Viz. mitochondria, chloroplast, golgi apparatus etc).

But in bacteria the cytoplasmic membrane have specialized **invagiantions that can increase** their surface area for certain function.

They are **well developed** in bacilli, and may be **2-4 in** number in **each cell**. Their number is **higher** in those bacteria involved in higher **respiratory activity** e.g. Azatobacter.

The mesosomes may be **central** or **peripheral** in position.

1.The central mesosome *penetrate-kirmoq* deeply into the cytoplasm and **located** near the middle of the cell, and **seemed** to be attached to the genetic material of the cell and *thought-deb o'ylanadi* to be involved in ***replication of DNA*** and ***cell division.***

2.While the peripheral mesosome show only a *shallow-sayoz* penetration into the cytoplasm seem to be involved in **export of exocellular enzymes** *such as penicillinase-ferment*.

Ribosomes

Ribosomes are found in free floating conditions and are randomoly distributed in the cytoplasm. They constitute about **30% of the total weight of the bacterium** (10,000 -15000 ribosome in a bacterial cell). During protein synthesis a number of ribosomes are **held together by mRNA** and form polyribosomes. The number of ribosome is directly proportional to the rate of protein synthesis.

The ribosome of prokaryote are of **70s type**. Each 70s ribosome is composed of **two subunits** larger **50S** and a smaller **30S**. Ribosome of E. coli bacteria is made up of **63% RNA and 37%** protein or they are in 2:1 ratio.

Lamellae or Chromatophore:

Lamellar thylakoid or vesicles are **found in many photosynthetic bacteria. They are known as chromatophores.** Lamellae are synthesized by two unit membranes. These membranes are distributed throughout the cytoplasm. These chromatophore are hollow rounded structure with a diameter of about 300A 0. They bears **photosynthetic pigments**, enzyme required for light reaction, ETS system of photophosphorylation. They lack the enzyme required for dark reaction.

Cytoplasm

Cytoplasm is the part of bacterial cell surrounded by cell membrane. The **80%** of cytoplasm is **water**, rest is nucleic acid, protein, lipids, carbohydrates inorganic ions and compounds of low molecular weight. The cytoplasm of prokaryote lack cytoplasmic **streaming and cytoskeleton.**

GAS VACUOLES

Some bacteria living in aquatic habitat form **gas vacuoles** that provide *buoyancy-suza olish.* In light microscope these are bright, refractile bodies and can be made to collapse under pressure and there by lose their refraction. The wall is made up of protein ego Non pigmented members of phototroph bacteria like *Polynema*, *Holobacterium* & *Clostridium*

NUCLEAR MATERIAL

Like other prokaryote, bacteria lack a well defined nucleus. Its genetic material is designated under the area near the center of the cell and *regarded-nomlanadi* as **nucleoid/ chromatin** body or bacterial chromosome since it consist of sbgle circular DNA molecule in which all genes are linked.

It can be made visible under the light microscope by Feulgen staining which is specific for DNA. Under Electron microscopy it appears as a light area with a delicate fibrillar structure. Its size measures, about 1000 pkm in length and 3 nm in diameter. Its molecular weight is nearly 5 x 10 9.

It has about 4000 genome whose replication is by semiconservative method.

The bacterial chromosome differ from eukaryote chromosome in **lacking histone (basic) protein** however polyamines may be found to some of the phosphate group of the bacterial DNA. Polyamines are **small molecules rich in amino groups.**

Plasmid and Episomes

In many bacteria in **addition to nucleoid** there is an extra small circular DNA segment which is in the form of ring is **called Plasmid**. There replication is autonomous. This extrachromosomal DNA fragment was **first discovered by Lederberg(1952).**

They are extrachromosomal, self replicating and stably *inherited-irsiy*, whose size ranges from about 20-100 kb pairs (a bacterial chromosome is about 4000 kbp).

Plasmid has an **independent replication** and contain own system for *initiating-boshlash* and controlling the replication.

Two types of plasmids have been identified:

1.Conjugative Plasmid: It carries genes that promote the transfer of plasmids from host cell to a receipient cell by conjugation.

2.Non-conjugative Plasmid: It can't promote its own transfer by conjugation.

Episomes: are the plasmid which get integrated into the bacterial chromosomes. It was **discovered** by Jacob, Schaeffer and Wollman (1960)

Important characteristic of naturally occurring plasmids:

1. They replicate independently of the main chromosome.
2. They are species specific to one or few species of bacteria.
3. They can undergo reversible integration into bacterial chromosome.
4. A few plasmid can pick up and transfer chromosomal gene.
5. They can be transferred by conjugation.
6. They usually contain upto 40 genes.
7. They do not occur free in nature.

NUTRITION

Generally the bacteria are classified in **two nutritional types** on the basis of their nutrition requirement:

(1) Autotrophic

(2) Heterotrophic

Autotrophic

A very small group of bacteria possess this type of nutrition. Few bacteria possess **photosynthetic pigment bacteriochlorophyll** other than normal chlorophyll found in higher plants are called photosynthetic bacteria.

Thus autotrophic bacteria are of two types:

(i) Photosynthetic bacteria

(ii) Chemosynthetic bacteria

Photosynthetic Bacteria

This type of bacteria possess a special type of pigment **called bacteriochlorophyll**. Along with this other pigment viz. Bacteriviridin or chlorobium chlorophyll is **also found**.

These pigments are found **on spiral structures called chromatophores**. Like other higher green plants **they synthesize carbohydrate** by the fixation of atmospheric CO2.

Generally this fixation process **occur-sodir bo‘lmoq** in the presence of **sulphur** compounds which is mainly H2S (hydrogen sulphide).

Therefore it can be said that hydrogen sulphide is main hydrogen **source in photosynthesis in bacteria** and here sulphur is produced as byproduct in place of oxygen (produced in higher plants) in the chemical reaction.

The chemical reaction of photosynthesis is as follows

$CO2 + H2S \rightarrow (CH20)n + 2S + H20 + energy$ e.g.

Chromatium, Chlorobium and Chlorobacterium

Chemosynthetic Bacteria

Many bacteria uses the energy released from different type of chemical reactions for the conversion of carbon dioxide into carbohydrate (because they cannot utilize the photo energy due to lack of chlorophyll).

Therefore they use the energy released from the oxidation of certain substances sulphur and its **compound. Ammonia, Nitrites, Iron, Hydrogen, Carbon monoxide**, methane are certain chemical substances whose oxidation is carried out by certain bacteria and the energy released is used by these bacteria for the synthesis of food. The important chemosynthetic bacteria are as follows:

Sulphur Bacteria: The example of sulphur bacteria are **Thiobacillus**, **Beggiatoa and Thiothrix.** These bacteria *utilizes* the energy released by the oxidation of sulphur and its compounds.

For example Thiothrix oxidizes the hydrogen sulphide or mineral sulphides into sulphur. This sulphur get stored inside the bacteria and later get converted into sulphate.

2H2S + O2 → 2S + 2H2O + 122.2 kcal

2S + 2H20 + 302 → 2H2S04 + 248.4 kcal

Iron bacteria : These bacteria generally oxidize the ferrous ion into ferric ion and releases energy. Eg - *Leptothrix, Ballionella and Ferrobacillus*.

4FeCO3 + O2 + 6H20 ~ 4Fe(OH)3 + 4C02 + 81 Kcal

Hydrogen bacteria: These bacteria convert the molecular hydrogen into water utilize the energy released during chemical reaction. Eg - Bacillus, Pantrotrophus, Hydromonas.

2H2 + O2 ~ 2H20 + 137 Kcal

Nitrifying bacteria: These bacteria utilize the energy released from nitrogen compound.

They are generally of two types

(i) those who oxidize ammonia into Nitrous e.g. Nitrosomonas and Nitrobacter

(ii) who convert nitrite into nitrate e.g. Nitrococus and Bactoderma.

Along with this some chemo-organotroph bacteria are found who utilizes the carbon and its compound as a source of energy they are of following types :

(i) Methane bacteria : These bacteria convert and oxidize methane into carbon dioxide gas and water ego Methanococcus, Lactobacillus and Acetabacter.

(ii) Carbon bacteria : These bacteria use the energy released by the oxidation of carbon monoxide e.g. Bacillus oligocarbophilus. "

2CO + O2 ~ 2C02 + Energy

HETEROTROPHIC BACTERIA

Most of the bacterial species are hetrotrophic in nature i.e. utilize nutrition from other living being.

Though they lack the photosynthetic pigment they are unable to utilize solar energy. These bacteria with the help of enzymes convert the complex organic compounds in soluble form and absorb them.

These bacteria are classified into three types:

(a) Saprophytic

(b) Symbiotic

(c) Parasitic bacteria

(a) Saprophytic Bacteria : They survive on dead and deteriorating organic compound. These bacteria absorb nutrition from them. Firstly they convert the complex organic compound into soluble compound with the help of enzymes and then absorb them according to their requirement or absorb them conditionally.

These bacteria are involved in the **deteoration of dead bodies**. They also undergo the process of putrifaction and fermentation of protein and carbohydrate respectively.

They are **generally facultative parasites** or **obligate saprophyte**.

In case of facultative parasite, they can <u>*utilize*</u> nutrition <u>***acting***</u> as parasite on living beings in case the dead organic matter is unavailable to them.

(b) Symbiotic bacteria: Those bacteria which grow and develop in close beneficial partnership or association with other living organism are called symbiotic bacteria and the phenomenon is termed as symbiosis.

For example these, bacteria occur in the root nodules of leguminous plants where they fix free atmospheric nitrogen in the soil which is utilized by plants and plants in turn provide them carbohydrate and shelter for proper development ego Rhizobia spp.

(c) Parasitic bacteria: Those bacteria which feed themselves on living tissues (host) are called parasitic bacteria. They are transmitted to the host by means of air, water and food.

These bacteria *may be obligate parasite* or *facultative parasite* or *may pathogenic* or *non pathogenic.*

These bacteria cause well known *harmful diseases* in plants and animals ego Citrus Canker, Ring rot of potato in plants and tetanus, typhoid, tuberculosis and pneumonia in man.

REPRODUCTION IN BACTERIA

Bacteria generally reproduce very commonly by vegetative and asexual mode of reproduction.

No sexual reproduction was reported by many microbiologist but electron microscopic study reports the unidirectional genetic recombination among certain bacteria.

Reproduction in bacteria includes the following methods

(i) Vegetative reproduction It includes the following types

(1) Binary fission

(2) Budding

(3) Cyst

(4) Gonidia or segmentation

(1) Binary fission: The most common and most important mode of cell division which occur in bacteria when the environmental factor such as light, moisture, temperature are favourable is transverse binary fission.

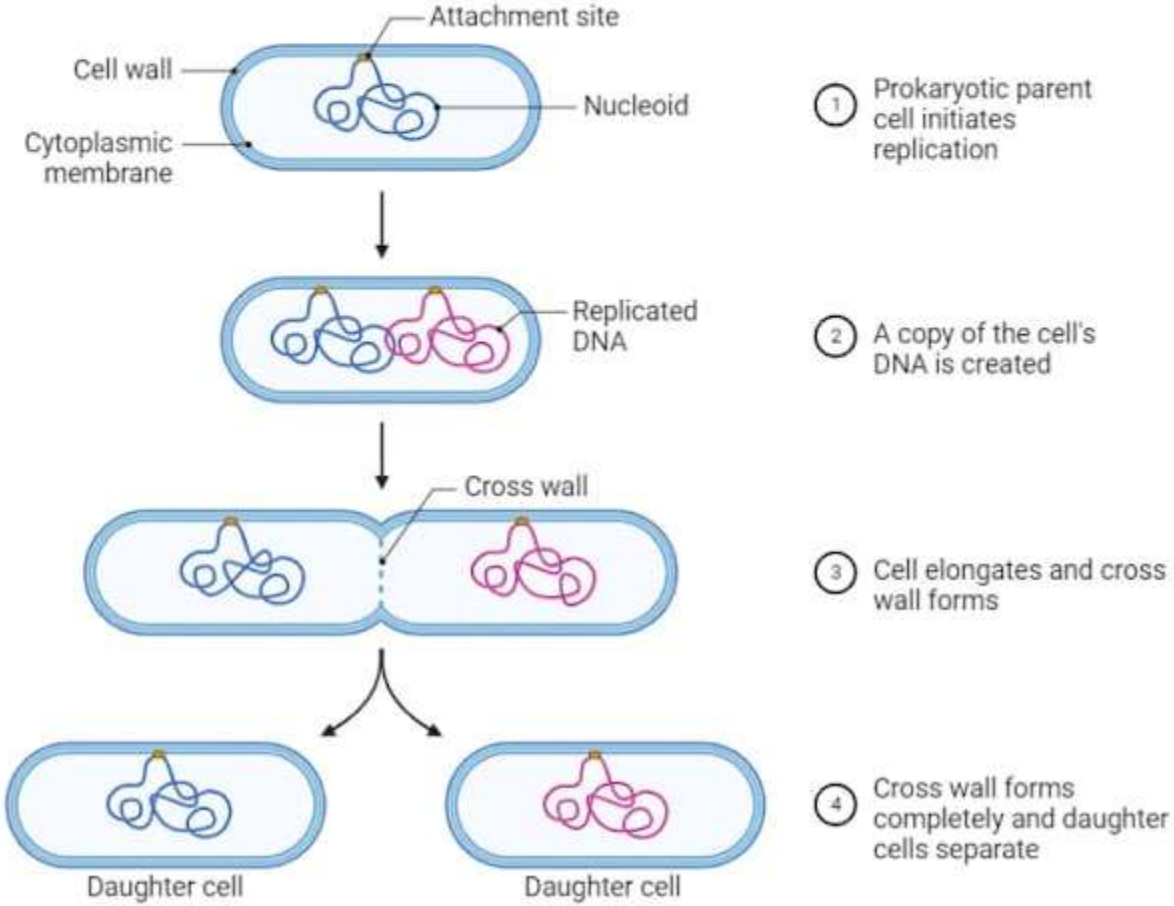
In this a *single cell divides* after developing a transverse septum (cross wall). Bacilli and spiral bacteria divide along the longitudinal axis of the cell while in coccus this division can be on any axis.

Mesosomes *play an important role in binary fission.*

Binary fission occurs in following steps:

(a) Division of nuclear or genetic material :

(b) Division of cytoplasm and septum formation


Attachment site
Cell wall
Nucleoid
Cytoplasmic membrane
1 Prokaryotic parent cell initiates replication
Replicated DNA
2 A copy of the cell's DNA is created
Cross wall
3 Cell elongates and cross wall forms
4 Cross wall forms completely and daughter cells separate
Daughter cell
Daughter cell

(a) Division of nuclear or genetic material : When bacterial cell attains its maximum size, it generally *increase* longitudinally.

After that its circular DNA undergo replication and results *into two DNA components*. This *replication is of semi conservative type*.

Now these *two DNA moves to two opposite poles with the help of mesosomes*.

Because no spindle fibres are formed during this entire process, this division is known as **amitosis.**

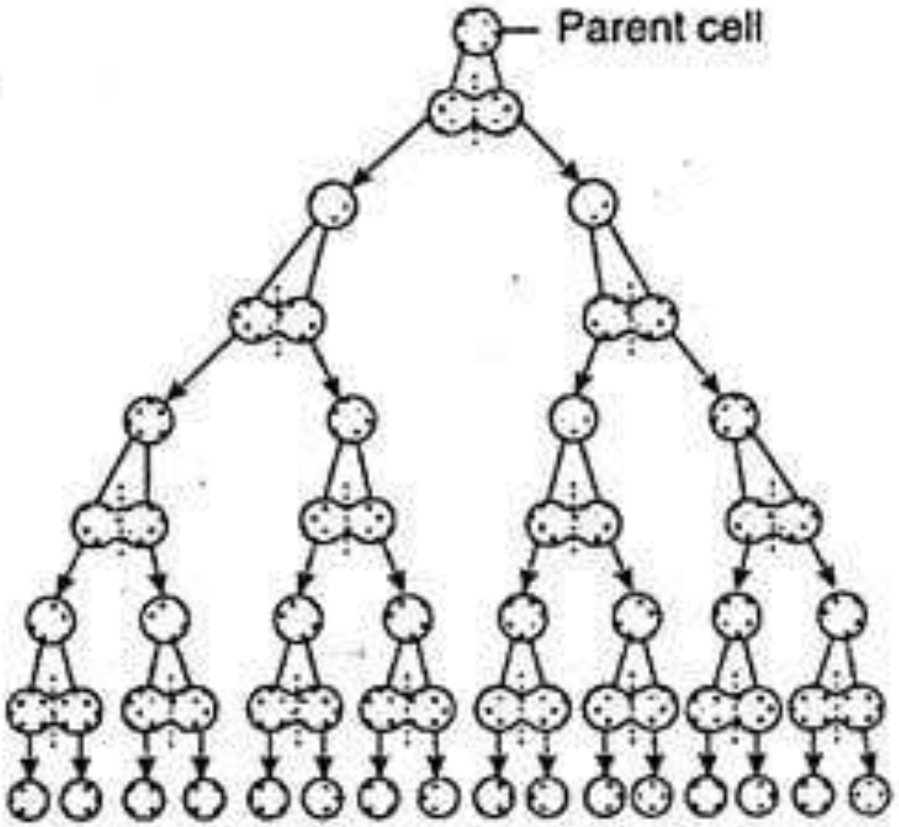


Fig. 2.19 : Binary fission results in rapid multiplication of bacterial cell

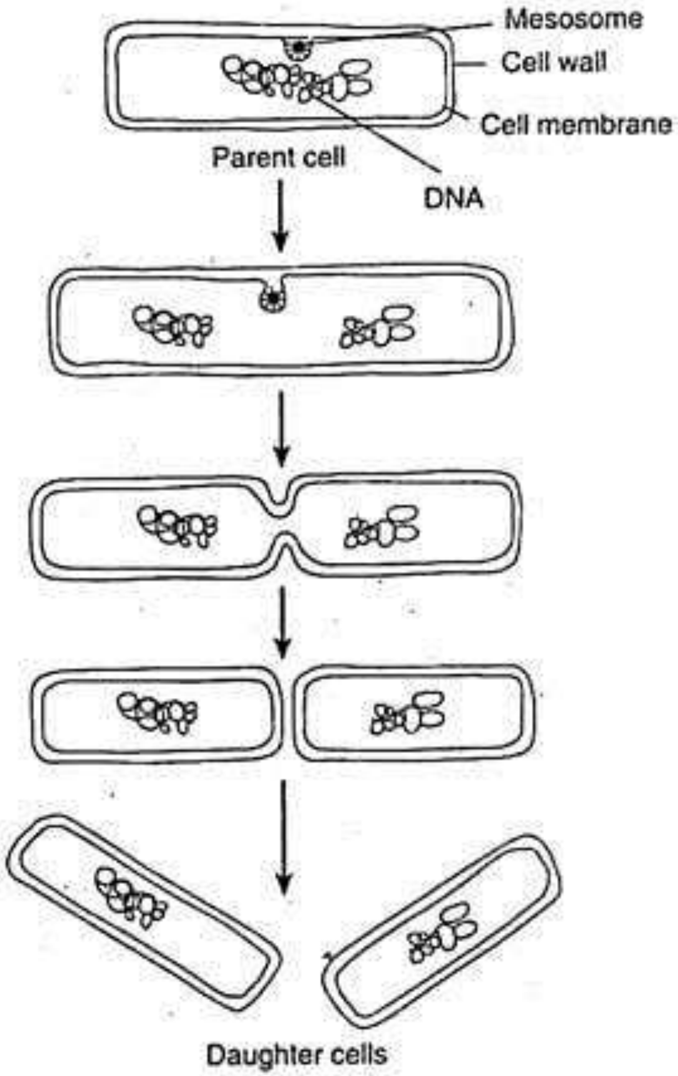


Fig. 2.20 : Binary fission of a bacterium

(b) Division of cytoplasm and septum formation:

By the end of the division of nuclear material, the *cytoplasmic membrane start invagination in the middle* of the cell.

This invagination is of centripetal direction and the inner most layer of cell wall also invaginate along with the L2 layer of plasma membrane and it forms the septum initial. This invagination appears as constriction on the cell surface. This constriction continuously deepens and results *into two daughter cells*. Under favourable conditions a single binary fission is completed **within 18-20 minutes.**

But such a rapid rate of cell division cannot continue for a long time because the rapid increase in growth rate of bacterial **population is inhibited** due to following reasons :

1. Lack of space, food, water, oxygen other salts and accumulation of their own harmful waste products in the medium.
2. Environmental factors like light, temperature, moisture becomes unfavourable.
3. Death due to senescence and sometimes they are eaten by microscopic animals and viruses.

Therefore survival rate of bacteria in nature is only 1 %.

(2) Budding:

In this type of process the bacterial cell wall gets thinned at the end of cell, and it develops a *cytoplasmic growth* or protuberance which is covered by thin membrane. This structure *is known as bud*. It contain the part of genetic material of the parent cell. This out growth increases in size and develops a constriction at its base and ultimately it gets separated from parent cell. Now this bud cell increases in size and attain the size of parent cell ego *Hypomicrobium.*

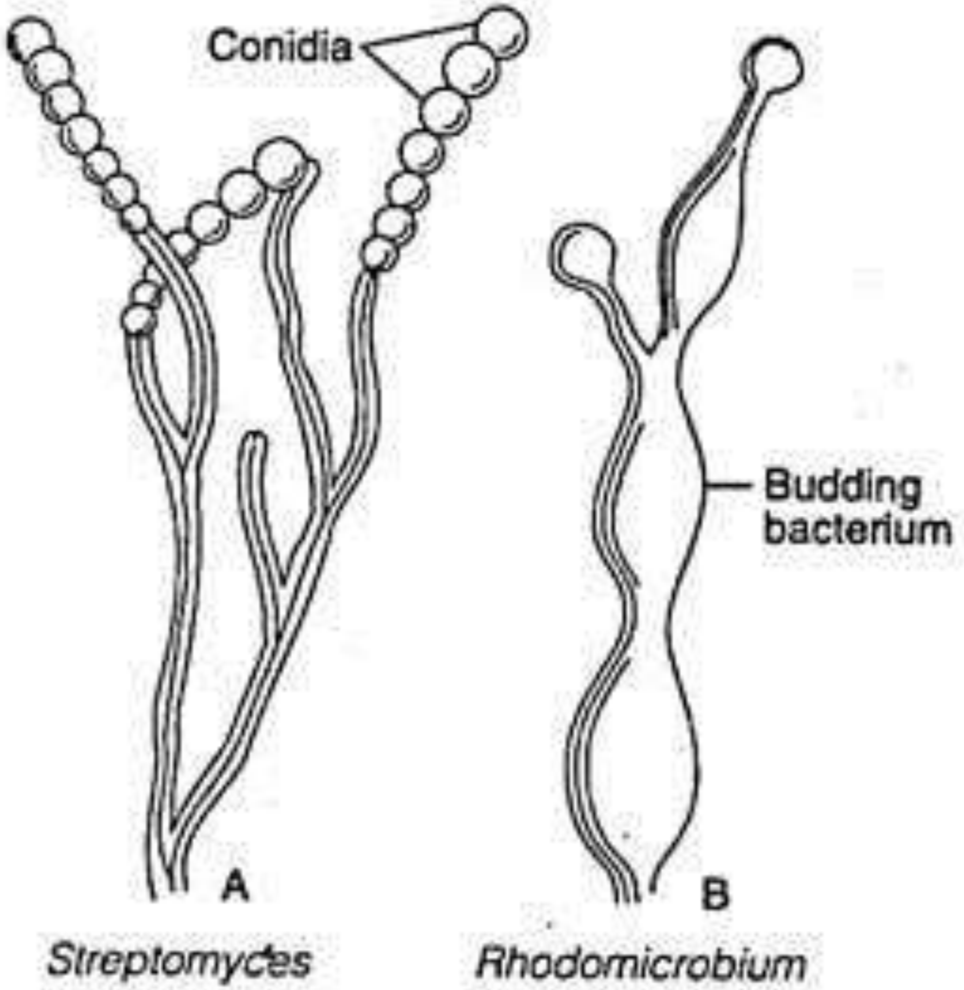


Fig. 2.21 : Asexual reproduction of bacteria : A. Conidia formation, B. Budding

(3) Cyst

Cyst formation is very *rare-kam* in bacteria ego Azotobacter.

Cyst is a spherical cell which is formed under unfavourable conditions. **Here the entire protoplast of the bacterial cells rounds up**, shortened, constricts and separated from the cell wall. After that a thick cell wall is formed around this entire structure. This structure is known as cyst and on germination it gives rise to a single vegetative cell.

(4) Gonidia or Segmentation

Bacteria which produces *extensive filamentous growth form gonidia*. Here such bacterial filament produces small *bacillary or coccoid* cells each of which give rise to new growth.

(ii) Asexual Reproduction: It is of following types :
Increase font size like Vegetative Reproduction.

(1) By Conidia

(2) By Oidiospores

(3) By Sporangiospores

(4) By Motile spores

(5) By Endospores

1. **By Conidia** Many bacterial species viz Streptomyces produces small minute disc like rounded bodies in chains at the tip of their filamentous structure. They are formed in chains. The filamentous bearing conidia is known as conidiophores. Conidia are formed in basipetal succession. Each conidium germinate and produce new filamentous bacterium.
2. **By Oidiospores** The entire filamentous structure of certain species of Actinomyces become septate at its end. Thus numerous micro size reproductive units are formed which are known as oidiospore. Each oidium on germination give rise to new filamentous bacteria.
3. **By Sporangiospores** Many branched filamentous bacteria become swollen at its terminal end and form sporangia. The cytoplasm of these sporangia divided to form small sized sporangiospore which on germination give rise to new filamentous bacteria under favourable condition.

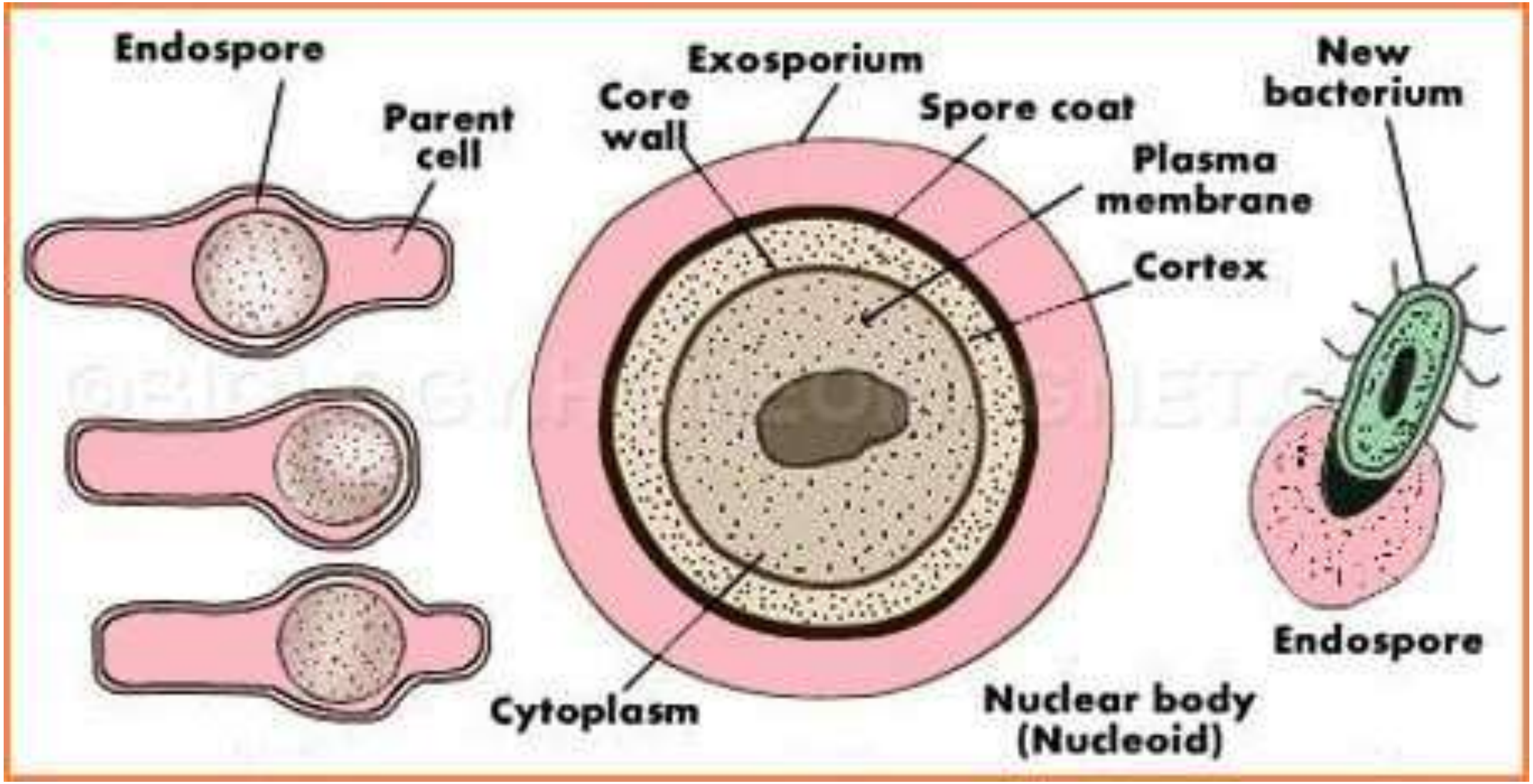
(4) By Endospore Endospore formation occurs in bacteria to tide over unfavourable environmental conditions. They are produced under conditions of limited supply of carbon, nitrogen and phosphorous.

This process was first of all reported by Cohn (1817) and late by Koch (1877). Endospores are generally formed in bacteria pathogenic to plants, animals and human beings. Endospores are heat, chemical, drying, freezing and radiation resistant bodies.

They can survive under dormancy even upto 50 years and on getting favourable environmental conditions they may germinate to start a new bacterial life.

Endospores are found in bacteria like Bacillus, Clostridium, Sporolactobacillus, Sporosarcina and Desulfotomaclllu111.

Generally a single cell transform into a single endospore but in certain cases two endospores are also reported from a single cell. They may be oval, ellipsoidal or spherical in shape and usually in central, terminal or sub-terminal in position.



Endospore
Parent cell
Core wall
Exosporium
Spore coat
Plasma membrane
Cortex
New bacterium
Cytoplasm
Endospore
Nuclear body (Nucleoid)

Thus endospore is a highly resistant structure. The resistant nature is due to following reasons:

(i) Lowest metabolic activities.

(ii) Very few amount of water.

(iii) Impermeable and protective nature of spore coat.

(iv) Lack of active enzymes.

(v) High percentage of Ca+2 ion in spore composition.

(vi) Presence of stabilizer compound i.e. Picolenic acid.

JINSIY- REPRODUCTION OR GENETIC RECOMBINATION

Unlike other prokaryote no true sexual reproduction is found in bacteria because (a) they lack sexual structures (b) no gametic fusion takes place. Karyogamy and meiosis is also absent in bacteria. Bacteria are haploid organisms. Gene transfer in bacterial cell donot produce zygotes but partial diploid called mero-zygotes. The original genome of recipient is named as endogenate. While the portion of DNA introduced from donar cell into recipient cell is called exogenome. However three different mechanism were later discovered for transferring gene or genetic material from one bacterial cell to another.

These mechanisms in order of their discovery are:

(i) Transformation

(ii) Conjugation

(iii) Transduction

(i) Transformation: It was first observed by Griffith (1928) who noted the transformation of harmless Pneumococci into virulent ones. Here there is transfer and expression of naked DNA from donor to recipient cell of bacteria takes place.

Transformation was discovered by Fredrick Griffith (1928) an English microbiologist while working on two strains of Diplococcus pneu11lolliae (new name Streptococcus pneumoniae). He reported that DNA is a genetic material.

Griffith used two strains of D. p"eu11loniae (i) bacteria with smooth and capsulated cell wall called as SIll (virulent or pathogenic)

CONJUGATION: Conjugation is the commonest process of sexual reproduction in bacteria. In conjugation two parental cells physically contact between two genetically different cells of the same or closely related species and transfer their genetic material through a small tube like projection called conjugation tube. The genetic material from one cell (donor or male) is transferred to other (recipient or female).

TRANSDUCTION This mode of gene exchange or reproduction was reported by Zinder and Lederberg (1952) in those forms of bacteria which are responsible for mouse typhoid (Salmonella typhimurium). Transport of bacterial DNA of donor cell to the recipient cell with the help of bacteriophage or transduction is the bacteriophage mediated transfer of genetic material of donor bacterial cell to the recipient bacterial cell. Transduction has been reported in E.coli, Proteus, Schizella and Staphylococcus. Zinder and Lederberg (1952) initially began their experiments with the objective of discovering whether the E. coli type of genetic exchange also existed in *S. hjphimurium.*

Mikroorganizmlar uglerod o’zlashtirishiga va energiyaning manbasiga ko’ra 4 ta guruhga bo’linadi.

1. **Fototroflar (avtotroflar)–** bu turli bakteriyalar uchun energiya manbai sifatidadagi yorug’lik kerak
2. **Xemotroflar** – bu turli bakteriyalarga energiya manbai sifatidagi kimyoviy moddalardan oladi
3. **Avtotroflar** – uglerodni bevosita karbonat angdriddan o’zlashtira oladilar. Avtotroflarning ba’zilari polietilen, fenol va boshqa anorganik moddalarni ham o’zlashtirishi mumkin.
4. **Geterotroflar** – faqat tayyor organik birikmalardan uglerod manbalari sifatida foydalanadi. Hozirgi yangi klassifikasiyaga binoan autotroflar litotroflar deb nom olgan.

Geterotrof ham esa bo‘linadi.

1. **saprofitlar**
2. **parazitlar**

Saprofitlar – lotincha bo’lib, ulgan **substratda yashaydigan degan ma’noni bildiradi.**

Tayyor organik birikmalardan foydalanadi va yer yuzidagi mikroorganizmlarning ko’pini tashkil qiladi.

Mikroorganizmlarning nafas olishi. Ma’lumki atmosfera tarkibida taxminan 21 % kislorod bor. U muhim ro‘l o‘ynaydi. Bakteriyalarning nafas olishi bu murakkab jarayon bo’lib, mikroorganizmlarga turli organik birikmalarni sintezlash uchun kerakli energiya shu tufayli hosil bo’ladi.

Mikroblar kislorodsiz muhitda ham yashashlari mumkin. Bu jarayonni *L.Paster isbotlagan*.

Mikroorganizmlar kislorodga bo'lgan munosabatiga qarab **2 guruhga bo'linib o'rganiladi.**

1. **Aeroblar – (aer-havo)** – havodagi erkin kislorod bilan nafas oluvchi mikroorganizmlar

2. **Anaeroblar (an-yo'q)-** havodagi erkin kisloroddan nafas olmaydigan mikroorganizmlar.

Ammo ular orasida keskin chegara yo‘q.

1. **Obligat aeroblar** – qat’iy aeroblar bo’lib, zich yoki suyuq oziq muhitlarning yuzida yashaydi. Masalan: *brusellez, sil mikroblari*

1. **Mikroaerofillar** – kislorodga kamroq muhtoj kislorodning oziqa konsentrasiyasi bu gruppa mikroblarni o’ldirmasada, ularning o’sishini, rivojlanishini susaytiradi.

1. **Obligat (qat’iy)** anaeroblar molekulyar kislorodsiz sharoitda rivojlanadi va molekulyar kislorodning zaharli rivojlanishini to’xtatuvchi faktor bo’ladi.

1. **Bak.anaeroblar** molekulyar kislorodning bor yo’qligiga qaramay yashaydi va rivojlanadi (ko’pchilik patogen va saprofit mikroorganizmlar).

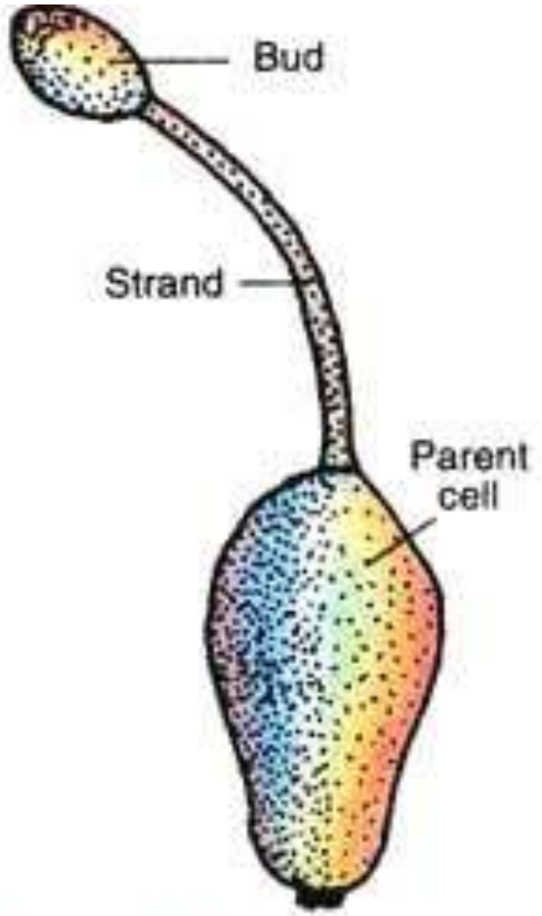


Fig. 18.9. *Bacteria*. Showing budding in the Hyphomicrobiales.

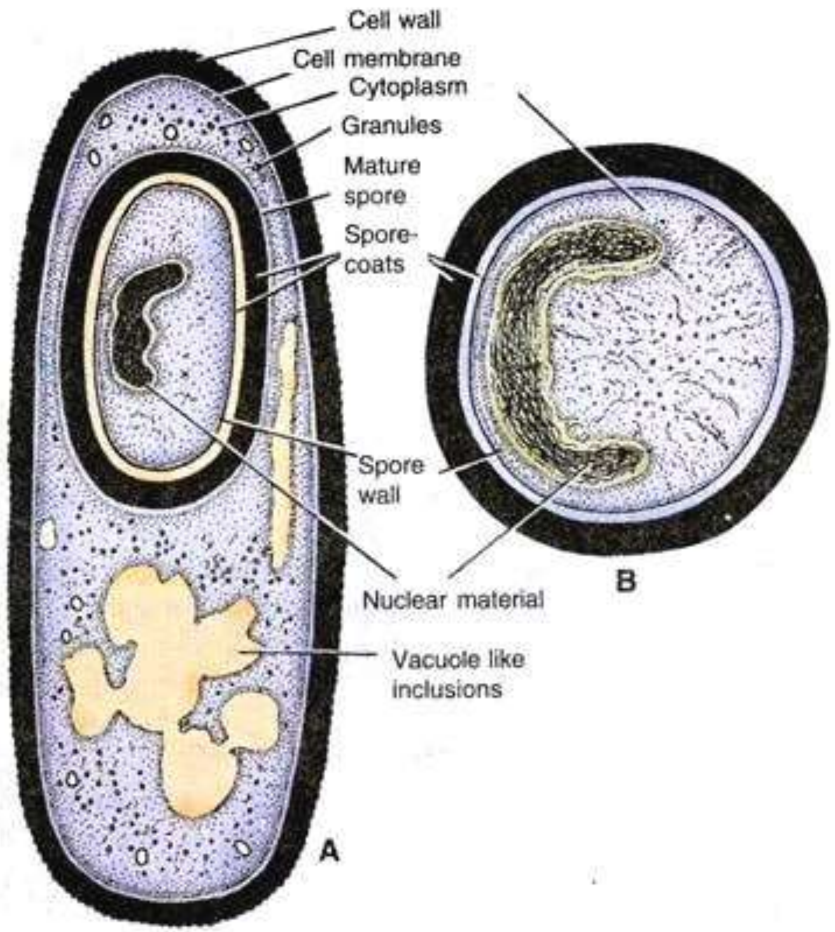


Fig. 18.12 (A-B). *Bacteria.* Structure of endospore. A, Sporangium containing a single sub-terminal endospore: B, cross-section of endospore (Diagrammatic).

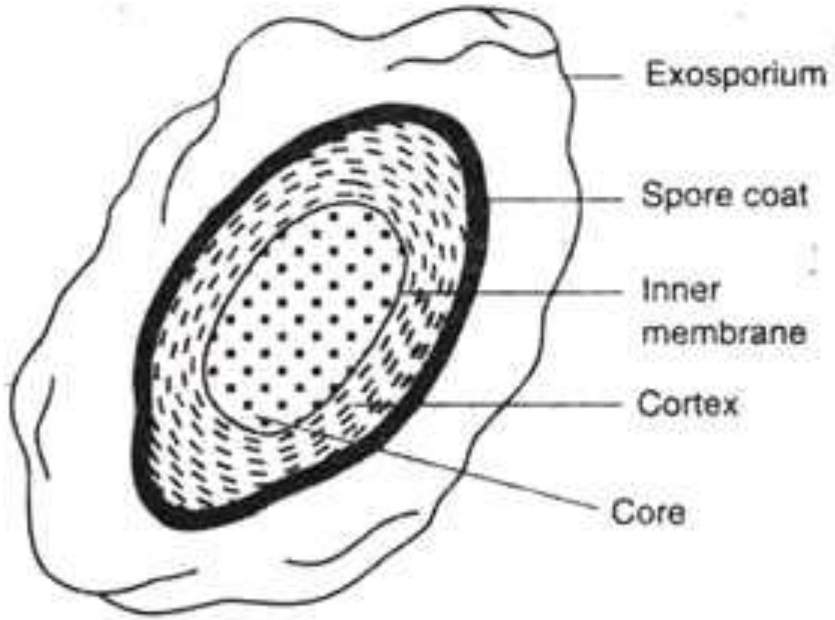
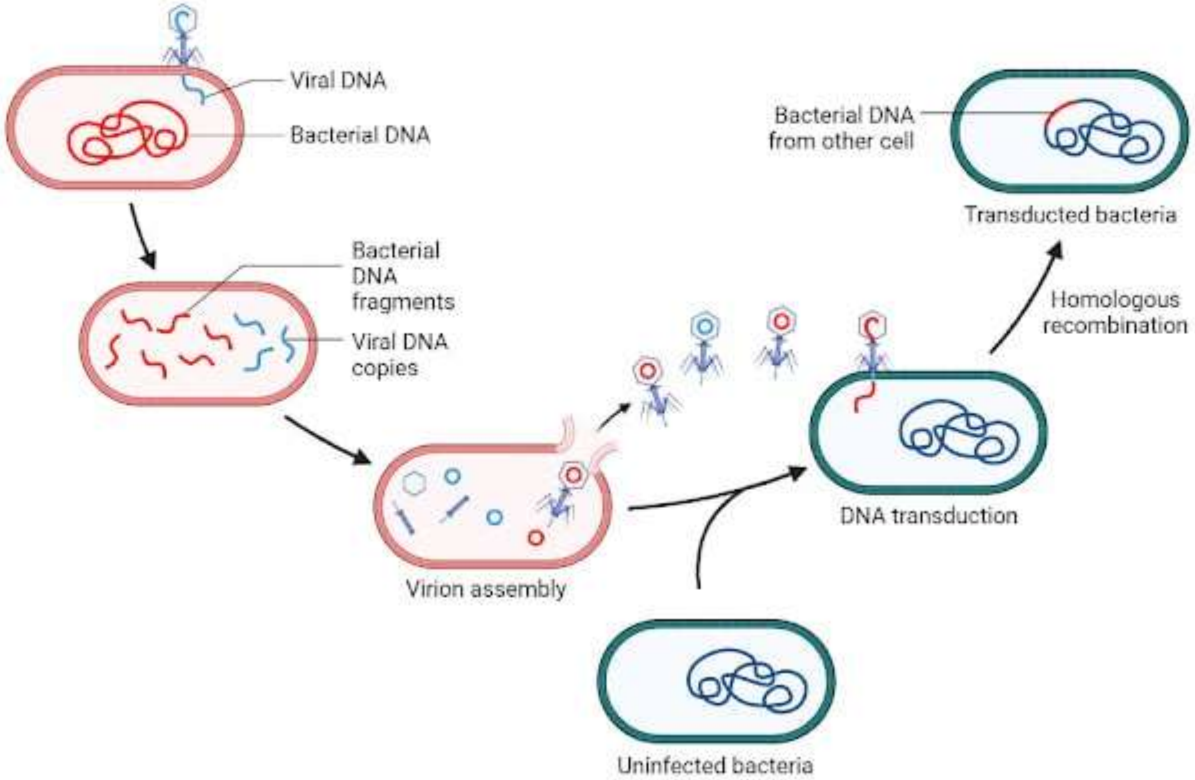
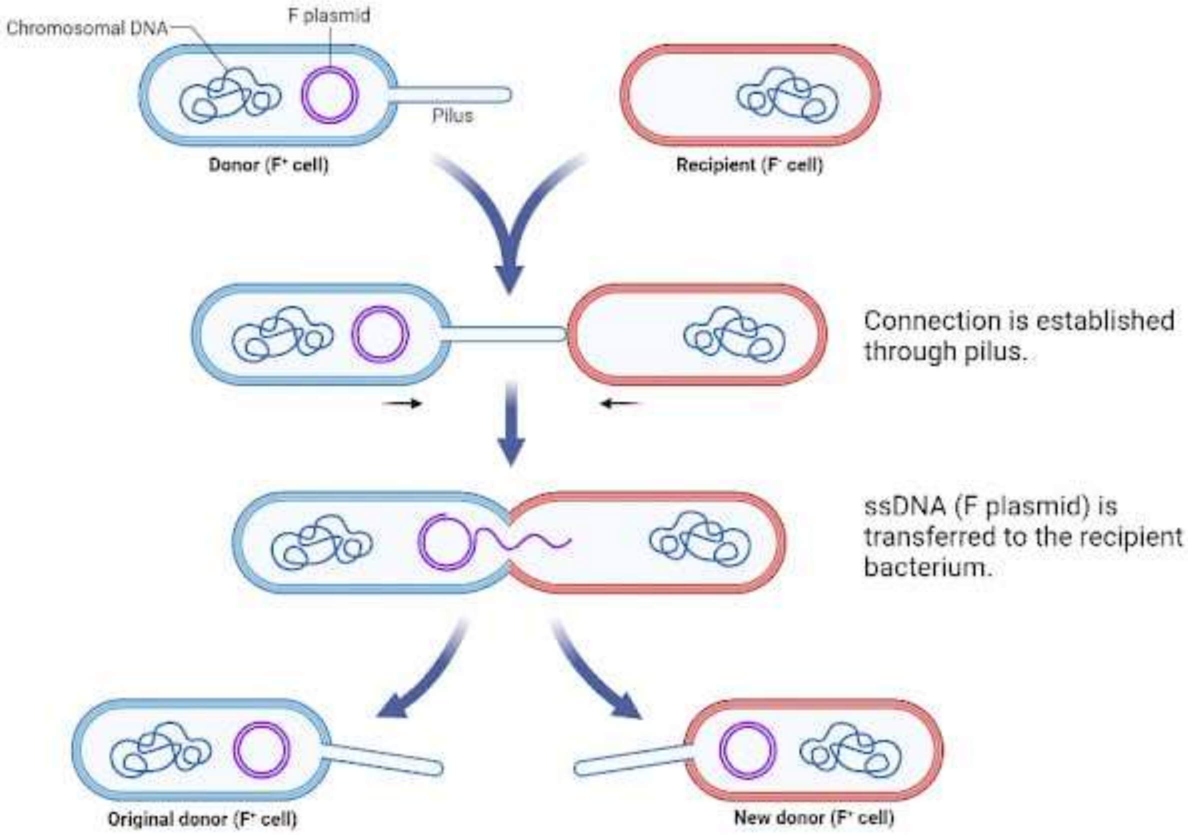


Fig. 2.23 : Bacterial endospore (diagrammatic representation)


Viral DNA
Bacterial DNA
Bacterial DNA fragments
Viral DNA copies
Virion assembly
DNA transduction
Uninfected bacteria
Bacterial DNA from other cell
Transducted bacteria
Homologous recombination


Chromosomal DNA
F plasmid
Pilus
Donor (F^+ cell)
Recipient (F^- cell)
Connection is established through pilus.
ssDNA (F plasmid) is transferred to the recipient bacterium.
Original donor (F^+ cell)
New donor (F^+ cell)