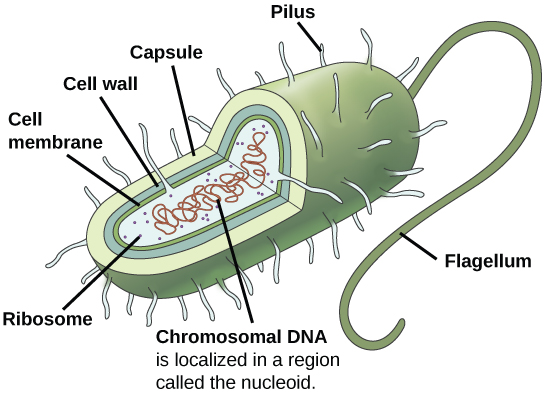
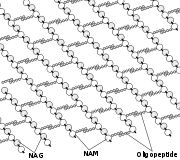
**Basic Structures of Prokaryotic Cells** Prokaryotes are unicellular organisms that lack organelles or other internal membrane-bound structures . Therefore, they do not have a nucleus, but, instead, generally have a single chromosome: a piece of circular, double-stranded DNA located in an area of the cell called the nucleoid. Most prokaryotes have a cell wall outside the plasma membrane.  
  


## 

## cell wall :

[](https://en.wikipedia.org/wiki/File:Mureine.svg)

The structure of [peptidoglycan](https://en.wikipedia.org/wiki/Peptidoglycan).

cell wall:

## A cell wall is a structural layer surrounding cell membrane. It can be tough, flexible, and sometimes rigid. It provides the cell with both structural support and protection, and also acts as a filtering mechanism.  They may give cells rigidity and strength, offering protection against mechanical stress.

Outer covering of most cells that protects the bacterial cell and gives it shape

► the primary function of the cell wall is to protect the cell from internal [turgor pressure](https://en.wikipedia.org/wiki/Turgor_pressure)((ضغط الامتلاء caused by the much higher concentrations of proteins and other molecules inside the cell compared to its external environment.

►composed of [peptidoglycan](https://en.wikipedia.org/wiki/Peptidoglycan) which is located immediately outside of the [cytoplasmic membrane](https://en.wikipedia.org/wiki/Cytoplasmic_membrane). Peptidoglycan is made up of a polysaccharide backbone consisting of alternating [N-Acetylmuramic acid](https://en.wikipedia.org/wiki/N-Acetylmuramic_acid) (NAM) and [N- acetylglucosamine](https://en.wikipedia.org/wiki/N-acetylglucosamine)  (NAG) residues in equal amounts.

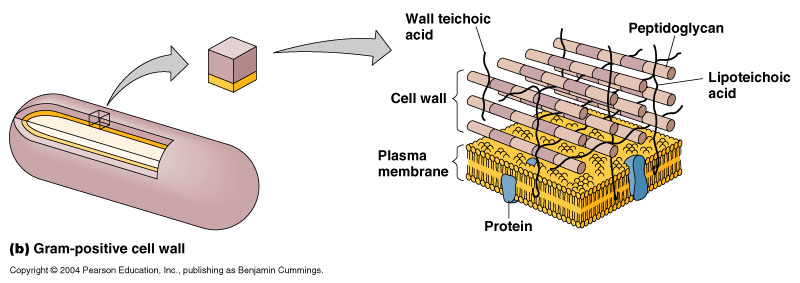
►There are two main types of bacterial cell walls, [gram-positive bacteria](https://en.wikipedia.org/wiki/Gram-positive_bacteria) and [gram-negative bacteria](https://en.wikipedia.org/wiki/Gram-negative_bacteria), which are differentiated by their [Gram staining](https://en.wikipedia.org/wiki/Gram_staining) characteristics. For both these types of bacteria, particles of approximately 2 nm can pass through the peptidoglycan. If the bacterial cell wall is entirely removed, it is called a [protoplast](https://en.wikipedia.org/wiki/Protoplast) while if it's partially removed, it is called a [spheroplast](https://en.wikipedia.org/wiki/Spheroplast)

**Gram positive bacterial cell wall**

### The gram-positive cell wall

Gram-positive cell walls are thick and the peptidoglycan ( also known as *murein*) layer constitutes almost 95% of the cell wall in some gram-positive bacteria and as little as 5-10% of the cell wall in gram-negative bacteria.

◙The gram-positive bacteria take up the [crystal violet](https://en.wikipedia.org/wiki/Crystal_violet) dye and are stained purple. The matrix substances in the walls of gram-positive bacteria may be polysaccharides or [teichoic acids](https://en.wikipedia.org/wiki/Teichoic_acid). There are two main types of teichoic acid: ribitol teichoic acids and glycerol teichoic acids. However, the exact function of teichoic acid is debated and not fully understood. A major component of the gram-positive cell wall is [lipoteichoic acid](https://en.wikipedia.org/wiki/Lipoteichoic_acid). One of its purposes is providing an antigenic function. The lipid element is to be found in the membrane where its adhesive properties assist in its anchoring to the membrane.



### The gram-negative cell wall

## Gram-negative cell walls are thin and unlike the gram-positive cell walls, they contain a thin [peptidoglycan](https://en.wikipedia.org/wiki/Peptidoglycan) layer adjacent to the [cytoplasmic membrane](https://en.wikipedia.org/wiki/Cytoplasmic_membrane). Gram-negative bacteria is stained as pink colour. The chemical structure of the outer membrane's lipopolysaccharides is often unique to specific bacterial sub-species and is responsible for many of the [antigenic](https://en.wikipedia.org/wiki/Antigen) properties of these strains. Lipopolysaccharides, also called [endotoxins](https://en.wikipedia.org/wiki/Endotoxin), are composed of polysaccharides and [lipid A](https://en.wikipedia.org/wiki/Lipopolysaccharide#Composition) which are responsible for much of the toxicity of gram-negative bacteria. It consists of characteristic lipopolysaccarides embedded in the membrane.

## https://upload.wikimedia.org/wikipedia/commons/thumb/8/8b/Gram_negative_cell_wall.svg/800px-Gram_negative_cell_wall.svg.png

## Gram-negative cell wall structure

## periplasmic Space

## ◙Periplasmic space is found in Gram-negative bacteria, between the inner and the outer membranes,

## ◙In Gram-positive bacteria, the periplasmic space is smaller and found between the polymer outer shell and the inner membrane.

## ◙The periplasm contains proteins and water and can be compared to cytoplasm. ◙Periplasmic enzymes play roles in motility, degradation of other compounds and transport.

Lipopolysaccharide

**1.**A compound or complex of lipid and carbohydrate.

**2.** a major component of the cell wall of gram-negative  bacteria;

**3.**The lipopolysaccharide (endotoxin) released from the cell walls of

gram -negative organisms that produces septic shock.

## 4- lipid protein known as lipid A

## ◙ dead cells release lipid A when cell wall disintegrates

## ◙ may trigger fever vasodilation , inflammation shock, and blood clotting

## ◙ can be released when antimicrobial drugs kill bacteria.

## Wall-less forms of Bacteria

## When bacteria are treated with

## 1- enzymes that are lytic for the cell wall e.g. lysozyme or

## 2- antibiotics that interfere with biosynthesis of peptidoglycan, wall-less bacteria are often produced Usually these treatments generate non-viable organisms.

## 3- Wall-less bacteria that can not replicate are referred to as sphero-plasts (when an outer membrane is present) or protoplasts(if an outer membrane is not present).

## 4- L-form bacteria, also known as L-phase bacteria, L-phase variants, and cell wall-deficient (CWD) bacteria, are strains of bacteria that lack cell walls .

## Components external to the cell wall

## Glycocalyx ( sugar coat)

## sticky ,gelatinous polymer outside the cell wall

## composed of polysaccharide, polypeptide or both

## if attached to cell wall , considered a capsule

## contributes to bacterial virulence

## important component of biofilms

## help attach to various surfaces, protects, facilitates communication (extracellular polymeric substance EPS)

## if unorganized and loosely attached, considered a slime layer

## http://player.slideplayer.com/26/8719493/data/images/img8.jpg

## Capsule

## layer of highly organized material external to composed of polysaccharide (usually ) or poly peptide (sometime e.g. Bacillus has D- glutamic acid )

## functional:

## ◙ protects it from dehydration

## ◙ protects against attack by phagocytic cells,

## ◙ increases its resistance to the immune responses.

## ◙ contributes to virulence of certain pathogens ( *Streptococcus pneumonia , Nisseria meningitides, Klebsiella pneumonia* ….etc…

## ◙ part of glycocalyx.

## Slime layer

## ◙ part of glycocalyx

## ◙ less well organized than capsules

## ◙ aid in adherence to surfaces (biofilms )

## ◙ Not as tight bound to cell as capsules

## ◙ protects against dehydration and loss of nutrients.

## نتيجة بحث الصور عن ‪Slime layer in prokaryotic cells picture‬‏

## S layer

## ◙ part of glycocalyx

## ◙ highly structured layer made up of protein or glycoprotein (crystalline)

## ◙ Adheres to outer membrane(OM) in gram negative bacteria

## ◙ Adheres to peptidoglycan (PTG) in gram positive bacteria

## Slime layer and S layer Provide protection from

## \* digestion by enzyme

## \*ingestion by bacteria

## \* ion and pH changes

## \* osmotic tress

## \*phagocytosis by leucocytes (virulence factor)

## \*Aide in adherence to surfaces (virulence factor)

## \*protects from complement attack (virulence factor)

## We are one step closer to combating biofilm and gram-negative bacteria

**Prokaryotic cell structure**

-[Flagellum](https://en.wikipedia.org/wiki/Flagellum) (only in some types of prokaryotes).

- Long, whip-like protrusion that aids cellular locomotion

- Confer motility

- 20 nm in diameter

- Helical

A **flagellum** (plural: **flagella**) is an appendage composed of protein flagellin . The primary role of the flagellum is locomotion, but it also often has function as a sensory organelle, being sensitive to chemicals and temperature outside the cell.

Consists of

1-filament

◙ from cell surface to top

◙ hollow made of flagellin protein

2- Basal body

◙ Embedded in cell

◙ Anchors flagellum

3-Hook

◙ hooks filament to the basal body

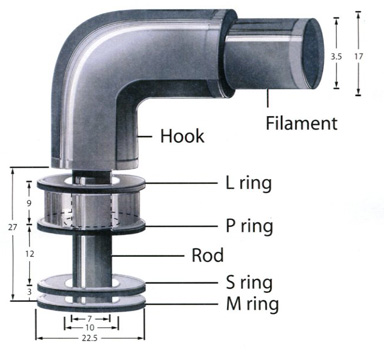
Basal body is made up of a series of rings

► gram negative bacteria have four rings connected to a central rod (L,M and S)

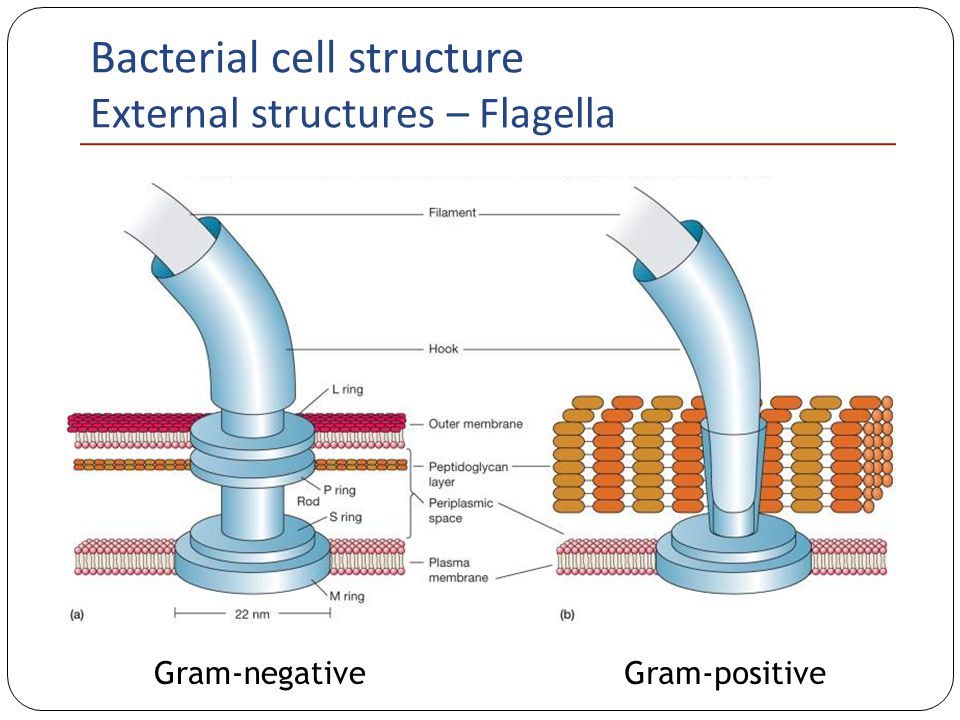
►gram positive bacteria have two rings

\* One attaches to PM

\* Other attaches to peptidoglycan PTG



Gram negative bacteria



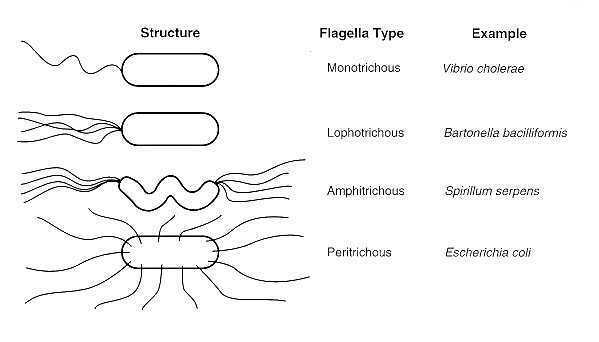
#### Flagellar arrangement schemes

Examples of bacterial flagella arrangement schemes.

A-monotrichous  
B-lophotrichous  
C-amphitrichous  
D-peritrichous

Different species of bacteria have different numbers and arrangements of flagella.

* Monotrichous bacteria have a single flagellum (e.g., [*Vibrio cholerae*](https://en.wikipedia.org/wiki/Vibrio_cholerae)).
* Lophotrichous bacteria have multiple flagella located at the same spot on the bacterial surfaces which act in concert to drive the bacteria in a single direction. In many cases, the bases of multiple flagella are surrounded by a specialized region of the cell membrane, the so-called polar organelle.
* Amphitrichous bacteria have a single flagellum on each of two opposite ends (only one flagellum operates at a time, allowing the bacterium to reverse course rapidly by switching which flagellum is active).
* Peritrichous bacteria have flagella projecting in all directions (e.g.,  *E. coli*).



**Function of bacterial flagella**

-Rotation propels bacterium through environment

-Rotation can be clockwise or counterclockwise reversible

- Bacteria move in response to stimuli (taxis)

◙ Runs – movements of cell in single direction for some time due to counterclockwise flagellar rotation; increase with favorable stimuli (positive chemotaxis, positive phototaxis)

◙ tumbles – abrupt , random changes in direction due to clockwise flagellar rotation; increase with unfavorable stimuli (negative chemotaxis, negative phototaxis).

**Fimbriae (Aka pili)**

◙ Very thin appendages (3-10nm in diameter)

◙ Involved in attachment, not motility

◙ Made of pillin (phosphate- carbohydrate protein complex)

◙ Often called adhesion



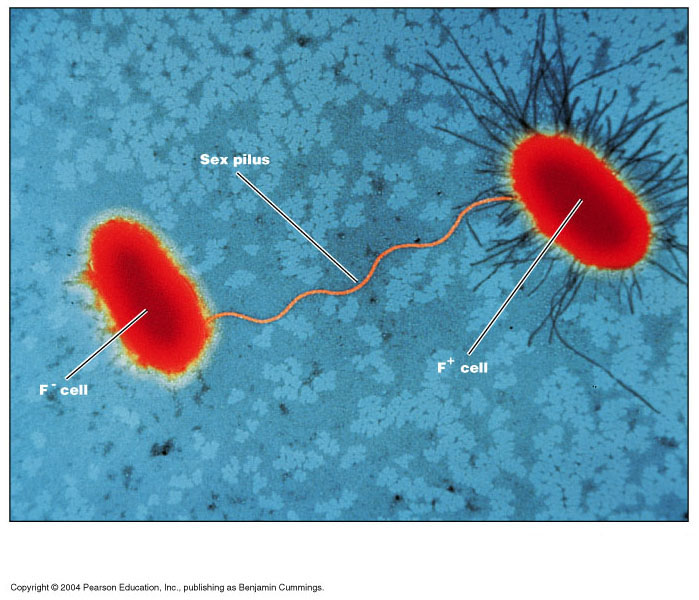
◙ Sex pilus

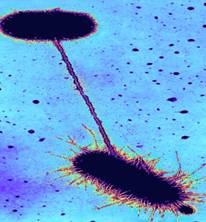
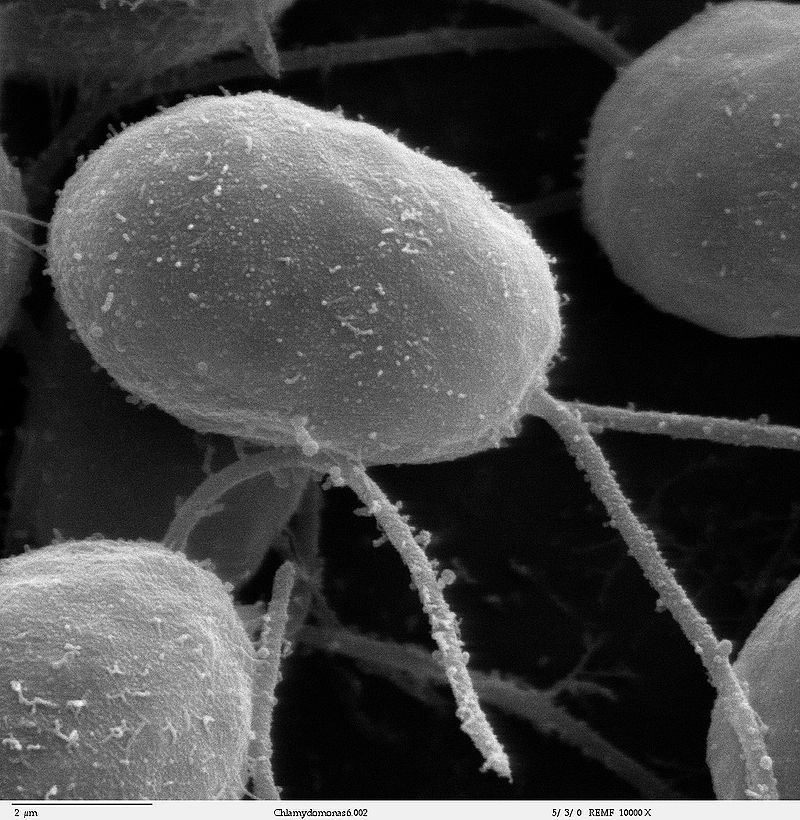
◙ Usually longer 9-10 nm in diameter

◙ Similar to fimbiae

◙ DNA transfer (conjugation)

◙ often have receptors for bacteriophages (filamentous phage)





## Cytoplasmic Membrane

The cytoplasmic membrane is a thin phospholipids bilayer (6 to 8 nanometers) that completely surrounds the cell and separates the inside from the outside.

Its selectively-permeable nature keeps [ions](https://www.boundless.com/biology/definition/ion/), [proteins](https://www.boundless.com/biology/definition/protein/), and other molecules within the cell,

preventing them from diffusing into the [extracellular](https://www.boundless.com/biology/definition/extracellular/) environment, while other molecules may move through the membrane.

**Cytoplasm of a prokaryotes:**

- The cytoplasm of a prokaryotic cell is everything that is present inside the bacterium..

- The cytoplasm houses all the chemicals and components that are used to sustain the life of a bacterium,

- The cytoplasm is bounded by the cytoplasmic membrane. Gram-negative bacteria contain another outer membrane. In between the two membranes lies the periplasm.

- The genome is apparent as a more diffuse area within the granular cytoplasm. This artificial structure has been called the nucleoid. Smaller, circular arrangements of genetic material called **plasmids** can also be present.

 Also present throughout the cytoplasm is the **ribonucleic acid** , various **enzymes** , amino acids, carbohydrates, lipids, ions, and other compounds that function in the bacterium. The constituents of the membrane(s) are manufactured in the cytoplasm and then are transported to their final destination.

- Some bacteria contain specialized regions known as cytoplasmic inclusions that perform specialized functions. These inclusions can be stored products that are used for the nutrition of the bacteria.

- Examples of such inclusions are glycogen, poly-B-hydroxybutyrate, and sulfur granules.

- As well, certain bacteria contain gas-filled vesicles that act to buoy the bacterium up to a certain depth in the water, or membranous structures that contain **chlorophyll** . The latter function to harvest light for energy in photosynthetic bacteria.

-The cytoplasm of prokaryotic cells also houses the **ribosomes** required for the manufacture of protein. The processes of **transcription** ,  **translation** , protein import and export

**Intracellular membrane**

Mesosomes

-Mesosomes are part of the structure of the plasma membrane, lining the cell wall.

- They are clumped and folded together, to maximize their surface area. This is important because it is needed for cell respiration, which is a function of the Mesosomes.

- They play a role in cellular respiration, the process that breaks down food to release energy.

- Mesosomes are the principal sites of respiratory enzymes, can easily be demonstrated in gram positive bacteria, are essential in bringing about cell division.

**Inclusion bodies**

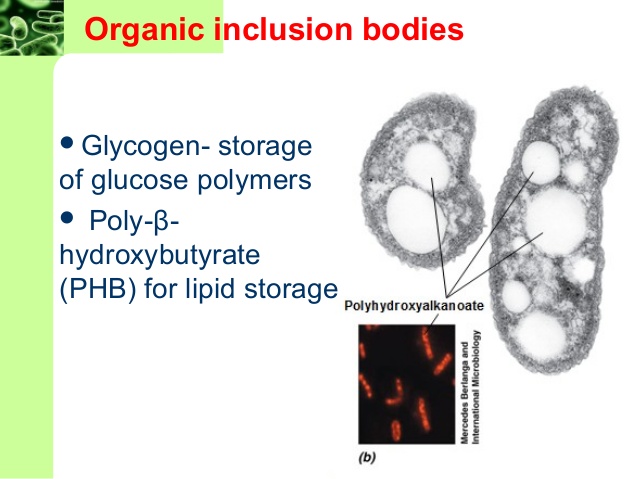
- Inclusion bodies are non-living substances present in the vacuoles, cytoplasm or cell wall.

- They are a kind of storage granules lying freely in the cytoplasm.

- The inclusion bodies are the bacterial cellular reserve materials.

**They are of two types:**

1. **Organic inclusion bodies**: They include cyanophycean starch granules and glycogen granules.
2. **Inorganic inclusion bodies**: They include polyphosphate granules and sulphur granules.



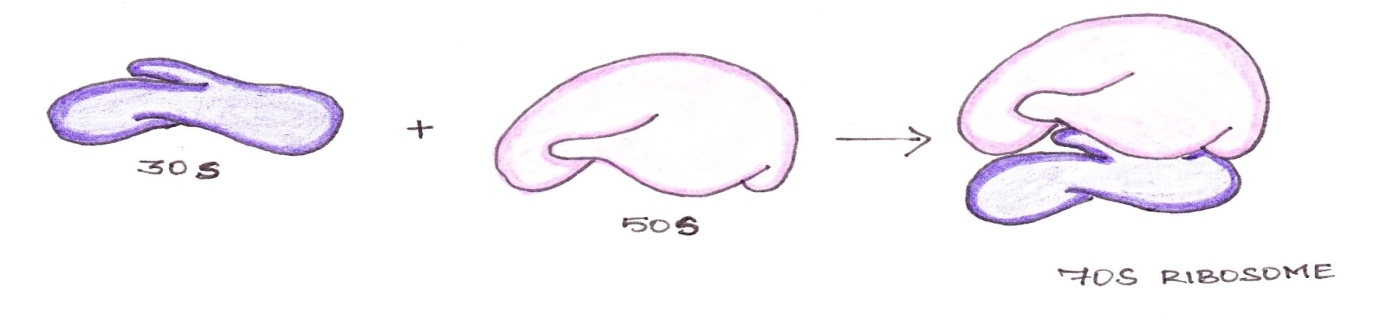
Ribosome

◙ The ribosome  is a simple molecular machine, found within all living cells, that serves as the site of biological protein synthesis (translation).

◙ Ribosomes link amino acids together in the order specified by messenger RNA (mRNA) molecules.

◙ Ribosomes consist of two major components: the small ribosomal subunit, which reads the RNA, and the large subunit, which joins amino acids to form a polypeptide  chain.

◙ Each subunit is composed of one or more ribosomal RNA (rRNA) molecules and a variety of ribosomal proteins. The ribosomes and associated molecules are also known as the *translational apparatus*.

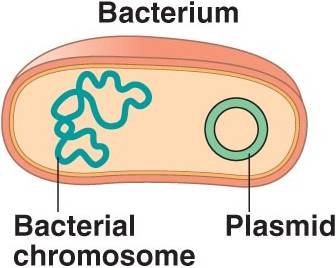


s=sedimentation coefficient…. affected by molecular weight , volume and shape

**Nucleiod Region**

 - Area of the cytoplasm that contains the single bacterial DNA molecule.

* Prokaryotic cells lack a **nucleus**
* They do have DNA, the DNA exists freely in the cytoplasm as a closed loop. It has no protein to support it and no membrane covering it. A bacterium typically has a single looped chromosome.
* **Plasmids** :
* Plasmids are gene carrying, circular DNA structures that are not involved in reproduction.



**Nucleiod:**

►nuclear body chromatin body, the DNA of bacteria is usually a single circular molecule located in the nucleiod

► nucleoids are present prior to cell division

►sometimes found to be associated with the plasma membrane or with mesosomes

**Spores**

►A bacterial spore is a structure produced by bacteria that is resistant to many environmental or induced factors that the bacteria may be subjected to.

► These spores help the bacteria to survive by being resistant to extreme changes in the bacteria's habitat including extreme temperatures, lack of moisture or being exposed to chemicals and radiation.

► Bacterial spores can also survive at low nutrient levels and antibiotics

►Most bacterial spores are not toxic and do not cause any harm, but some bacteria that produce spores can be pathogenic.

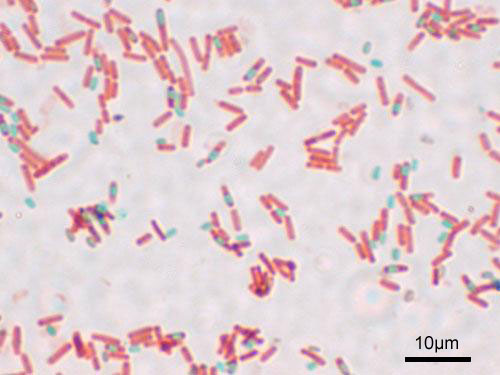
►Most spore-forming bacteria are contained in the bacillus and clostridium species but can be found in other species of bacteria as well.

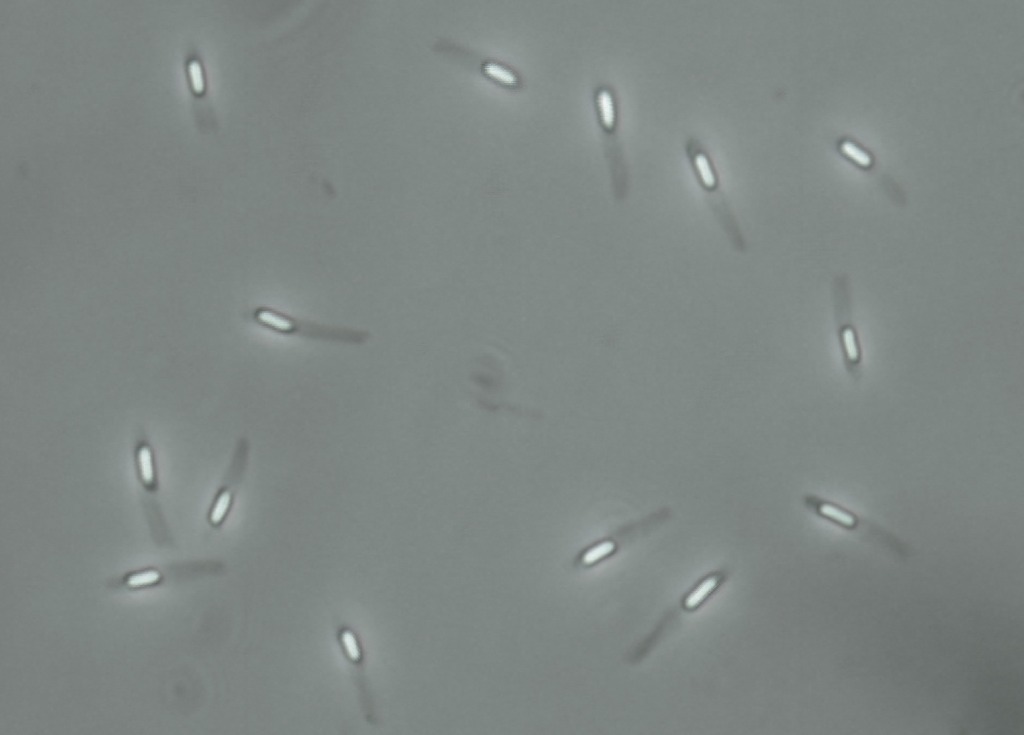
►There are different types of spores including endospores, exospores, and spore-like structures called microbial cysts.

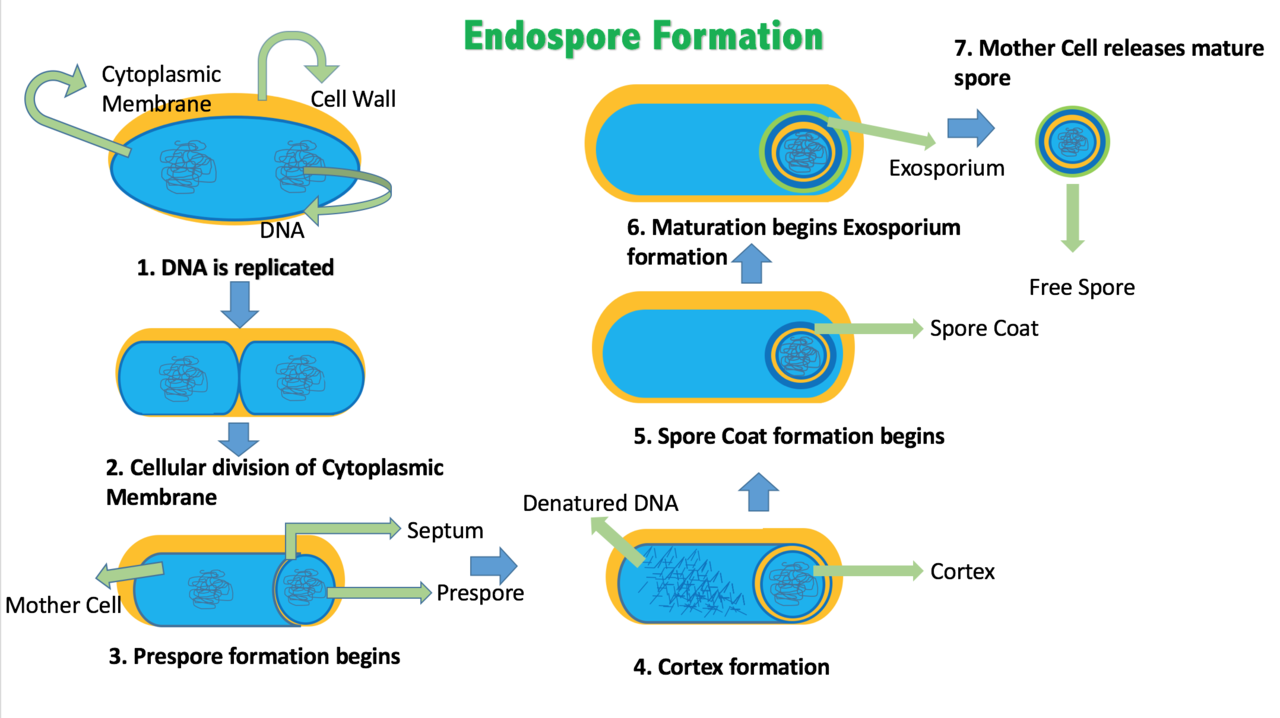
►Bacterial spores are extremely resistant. Spores of tetanus and anthrax, for example, can survive in the soil for many years.

►Under the microscope, a small, round, bright body inside bacterial cells. This survived even when the bacteria were boiled for five minutes. This killed the bacteria, but not the spores.

►They germinated when conditions were right. Because spores are so resistant, they are highly transmissible(معدي). This makes them a very problematic aspect of spore-forming pathogens such as *Clostridium* spp.







Sterilization and Disinfection

▀ Aseptic techniques to prevent contamination of surgical wounds. Prior to this development: Nosocomial infections (المكتسبة في المستشفيات) caused death in 10% of surgeries (بعض من هذه العدوى التي تحدث في المرضى بعد الدخول إلى المستشفى يسمى عدوى المستشفيات)

▀ Up to 25 % mothers delivering in hospitals died due to infection.

Sterilization

The process of freeing an article from microorganisms including their spores.

Disinfection:

Reducing the number of pathogenic microorganisms to the point where they no longer cause diseases.

Bacteriostatic Agent:

An agent that inhibits the growth of bacteria but dose not necessarily kill them.

Sepsis: Comes from Greek for decay or putrid. Indicates bacterial contamination.

▀ Asepsis: Absence of significant contamination.

▀ Aseptic techniques are used to prevent contamination of surgical instruments, medical personnel and the patient during surgery.

Bactericide or Bactericidal:

▀ An agent that kill bacteria , most do not kill endospores.

Sporicide:

▀ An agent that kills spores.

Methods of Sterilization

Microbial control methods

Physical Agents

Chemical Agents

Mechanical removal methods

Disinfection

Sterilization

Gas

Sterilization

Disinfection

Antiseptics

chemotherapy

Inanimate

Animate

Chemical Agent

Liquids

X ray cathode

Gamma

Sterilization

Steam under pressure

Dry oven

Incineration

Moist

Dry

Physical agents

Heat

Disinfection

UV

Radiation

Flaming

disinfection

Boiling water \ hot water pasteurization

Sterilization

None ionizing

Ionizing

Mechanical removal methods

Disinfection

Sterilization

Liquids

Air

Filtration

Uses

◙ to sterilize forceps, Scissors, Scalpels, Swabs.

◙ Pharmaceuticals products like liquid paraffin, dusting power, fats and grease.

**Incineration**

This is an excellent method of destroying materials such as contamination cloth, animal carcasses and pathological materials.

physical methods of sterilization

Sterilization by dry heat

۞ kills by oxidation effects

۞ the oven utilizes dry heat to sterilize articles

۞ operated between 50° C to 250-300 ° C

۞ a holding period of 160 °C for 1 hr. is desirable.

۞ there is a thermostat controlling the temperature

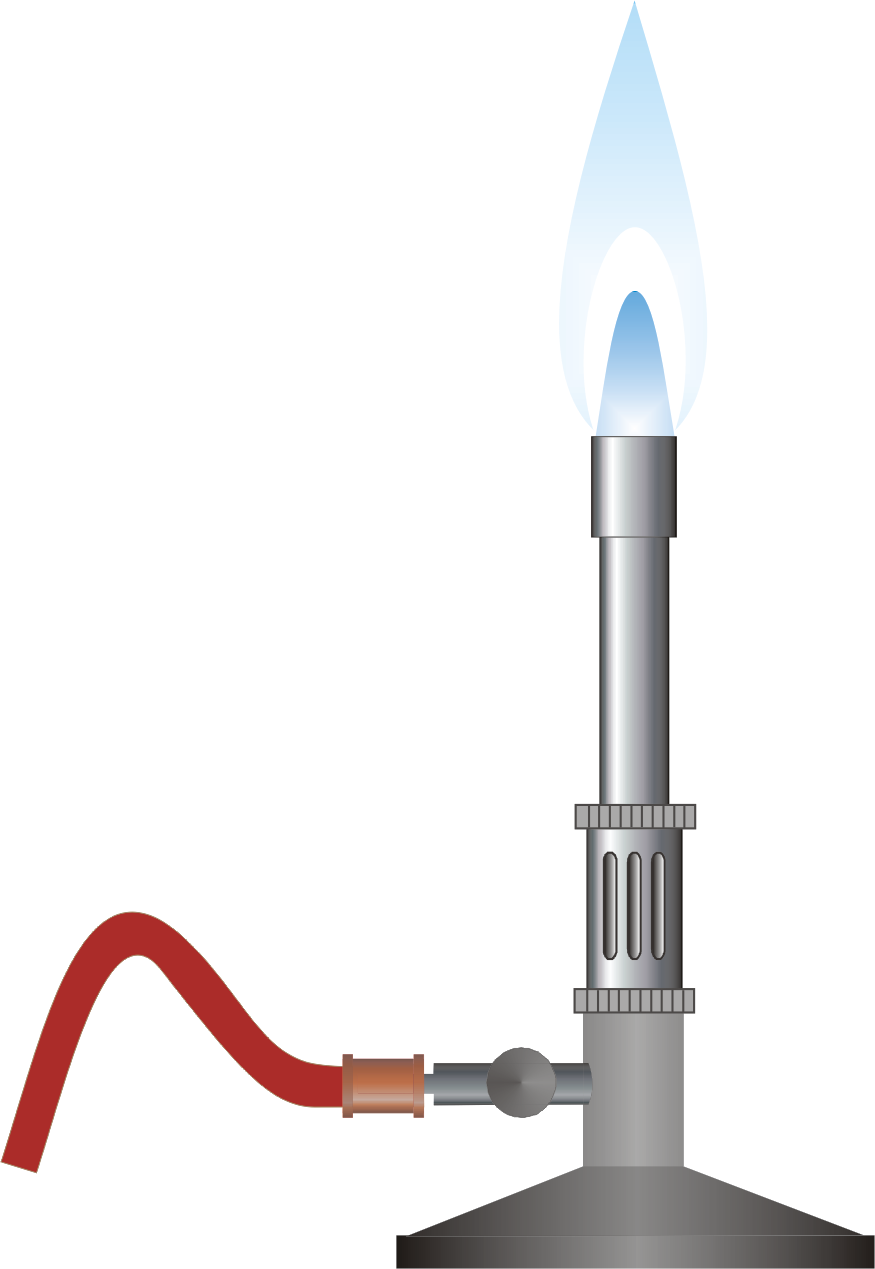
۞ double walled insulation keeps the heat in and conserves energy



1- Hot air oven

2- Flaming

۞ Inoculation loop or wire the tip of forceps and spatulas are held in a Bunsen flame till they are red hot .





B- Moist heat sterilization

◙ kills microorganisms by coagulating their proteins.

1- Pasteurization

◙ Process of killing of pathogens in the milk but dose not sterilize it .

◙ Milk is heated at 63 °C for 30 mins. (holder method)

◙ At 72 °C for 15-20 sec. rapid cooling to 13 °C (flash process).

**Moist heat sterilization is carried out with following methods**

**1-** Temperature below 100°C " pasteurization" .

2- Temperature at 100°C boiling.

3- Steam at atmospheric pressure " Koch\ Arnold's steamer

4- Steam under pressure "Autoclave"

Hot water bath

- To inactivate non sporing bacteria for the preparation of vaccines – Special vaccine bath at 60°C for one hour is used.

- Serum or body fluid containing

- Coagulable proteins can be sterilized by heating for 1 hr. at 56°C in water bath for several successive days.

Temperature at 100°C

Boiling:

- kills vegetative forms of bacterial pathogens.

► Hepatitis virus; can survive up to 30 minutes of boiling

► Endospores ; can survive up to 20 hours or more of boiling.

Steam at atmospheric pressure

- Steam is generated using a steamer (Koch\ Arnold)

- consists of a tin cabinet

- has a conical lid to enable the drainage of condensed steam

- perforated tray above ensures materials are surrounded by steam.

- for routine sterilization exposure of 90 min is used.

- for media containing sugar and gelatin exposure of 100°C for 20 min for 3 successive days is used.

█ the process is termed as

- Tyndallisation\ intermittent sterilization((التندلة او التعقيم المتقطع

Steam under pressure - Autoclave

-  is a pressure chamber used to carry out industrial processes requiring elevated temperature and pressure

- Autoclave consists of a vertical or a horizontal cylinder.

- Autoclaves are used in medical applications to perform sterilization and in the chemical industry to cure coatings and vulcanize rubber and for hydrothermal synthesis

-Many autoclaves are used to sterilize equipment and supplies by subjecting them to high-pressure saturated steam at 121 °C for around 15–20 minutes depending on the contents

- The autoclave was invented by Charles Chamberlandin 1879

- Typical loads include laboratory glassware, other equipment and waste, surgical instruments, and medical waste.

   
Alchohols

- Ethanol, isopropyl alcohol are frequently used.

- No action on spores

- Concentration recommended 60-90% in water

Uses:

- Disinfection of clinical thermometer.

- Disinfection of skin- venupuncture.

chemical agents

chemical agent act by:

- protein coagulation

-disruption of the cell membrane

-removal of sulphydryl groups

- substrate competition

Aldehydes

- formaldehyde is bactericidal , sporicidal and has a lethal effect on viruses

formaldehyde uses:

- to preserve anatomical specimens

-destroying Anthrax spores in hair and wool

- 10% formalin + 0.5% Sodium tetra borate ia used to sterilize metal instruments

Dyes

two groups of dyes are used:

1- Aniline dyes

- are brilliant green , malachite green and crystal violet

- Active against Gram positive bacteria

- no activity against tubercle bacilli.

2- Acridine dyes

- Acridine dyes are orange in colour

- Effective against Gram positive than Gram negative

- important dyes are proflavine, Acriflavine and Euflavine.

Halogens

- Iodine in aqueous and alcohol solution has been used widely as a skin disinfectant

- Actively bactericidal with moderate against spores

- Chlorine and its compounds have been used as disinfectants in water supplies and swimming pools.

Uses

- Specially used for sterilizing heart-lung machines , respirators , sutures , dental equipments, books and clothing

- used to sterilize Glass , metal and paper surfaces, plastics some food and tobacco

Gases

Ethylene oxide

-Colorless, highly penetrating gas with a sweet ethereal smell.

- Effective against all type of microorganisms including viruses and spores.

Formaldehyde gas

- Widely employed for fumigation of operation theaters and other rooms

Sterilization by filtration

Filtration helps to remove bacteria from heat labile liquids such as sera and solutions of sugars and antibiotics.

The following filters are used :

1- Candle filters

2- Asbestos filters

3- Sintered glass filters

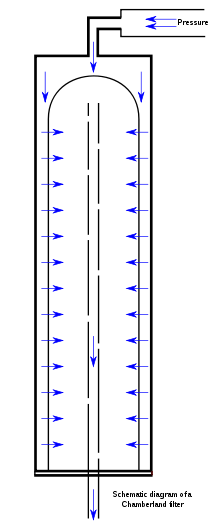
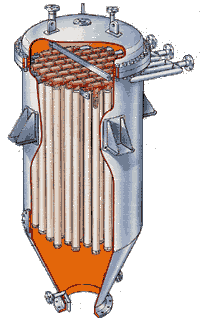
4- Membrane filters

Candle filters

- widely used for purification of water . There are two types:

a- Unglazed ceramic filter- chamberland filter

b- Diatomaceous earth filters- Berkefeld filters

chamberland filter candle filter

Asbestos filter

- disposable single use discs

- high adsorbing tendency

-carcinogenic

ex. Seitz filter



Sintered glass filter

- prepared by heat fusing powered glass particles of graded size

-Cleaned easily , brittle and expensive . 

Membrane filters

- made of cellulose esters or other polymers

uses:

- water purification and analysis

- sterilization sterility testing .

- preparation of solution for parenteral use



Non- ionizing radiation

- electromagnetic rays with longer wavelength.

- Absorbed as heat.

- Can be considered as hot air sterilization .

- Used in rapid mass sterilization of prepacked syringes and catheters

ex: UV rays

Radiation

Two types of radiations are used

1-Non- ionizing

2- Ionizing

Ionizing radiations

- X- rays, gamma rays and cosmic rays

- High penetrative power

- No appreciable increase in the temperature- cold sterilization

- Sterilize plastics Syringes , catheters, grease fabrics metal foils.

Transonic and sonic vibration

- bactericidal

- microorganisms vary in their sensitivity hence no practical value in sterilization and disinfection

Bacterial nutrition, Metabolism and growth