KINGDOM MONERA (PROKARYOTES)

- Copeland (1956) established kingdom Monera in which all prokaryotes were included.
- Bacteria are the sole members of the Kingdom Monera. They are the most abundant micro-organisms.
- Bacteria occur almost everywhere. Hundreds of bacteria are present in a handful of soil. They also live in extreme habitats such as hot springs, deserts, snow and deep oceans where very few other life forms can survive. Many of them live in or on other organisms as parasites.

Main Characteristic of Kingdom Monera (Prokaryotes)

Cell wall

- Cell wall of prokaryotes is made up, of pep Tidoglycan (murein) which is a type of mucopeptide.

Cell membrane

- Like eukaryotes the cell membrane of prokaryotes is made up of lipoprotein [lipid + protein]
- The space between cell wall and cell membrane is known as periplasmic space. This space, is analogous to lysosome because in this space the digestion of complex substance is done.

Cytoplasm

- The cytoplasm of prokaryotes lacks membrane bound cell organelles.
- In Prokaryotic cell, the nucleus is indistinct. The nucleus of prokaryotes is also known as incipient nucleus, genophore, nucleoid or fibrillar nucleus. Nuclear membrane is absent around nucleus. It also lacks nucleolus. Prokaryotes also lack the true chromosome. Instead of it, a false chromosome is present, which is made up of ds circular naked DNA+ Non histone protein like polyamines. This false chromosome coils and forms the chromosomal region, which is known as nucleoid.
- In prokaryotes ribosomes are of 70s type. Ribosomes are the site of protein synthesis.

Bacterial Life Processes

when we talk about bacteria, we focus on understanding their important life processes, such as breathing and eating.

1. **Respiration**

   bacteria can be categorized into two main groups based on how they breathe: aerobes (who need oxygen) and anaerobes (who don't). Within each group, there are two types: strict or obligate (meaning they have specific requirements) and facultative (meaning they can adapt).

2. **Nutrition**

   we classify bacteria into different groups based on what they eat, where they get their energy, and how they handle electrons.

   I. **Photosynthetic autotrophic bacteria**

   a) **Photolithotrophic bacteria**

   These bacteria can capture sunlight and use it to make their own food because they have special pigments like bacteriochlorophyll (bacteriopurpurin) and bacterioviridin.

   Purple sulfur bacteria (like Thiospirillum) and green sulfur bacteria (such as Chlorobium limicola) are common examples that have pigments called bacteriochlorophyll, bacteriopurpurin, and bacterioviridin, respectively. Unlike the photosynthesis in higher plants, bacterial photosynthesis doesn't release oxygen. This specific type of bacterial photosynthesis is called anoxygenic, while the regular photosynthesis in higher plants is termed oxygenic.

In bacterial photosynthesis, the electrons needed to convert CO_2 into glucose don't come from water. Instead, bacteria use various compounds like hydrogen sulfide, thiosulphate, or even some organic compounds to obtain reducing power. The hydrogen released by these compounds is taken up by NAD^+, which becomes reduced to $NADH_2$, acting as the reducing power. NADH, along with ATP produced by capturing solar energy, is used to reduce CO_2 to glucose. A simple equation for anoxygenic photosynthesis can be written as:

$$CO_2 + H_2S \text{ (or any other compound acting as electron } \xrightarrow[\text{enzyme}]{\text{solar energy}} \text{Sugar} + \text{(sulphur or other oxidised compound)} + H_2O$$

No oxygen is produced because it doesn't require splitting water.

b) Photoorganotrophic bacteria :

Some bacteria that undergo photosynthesis get their electrons and carbon from organic matter. The majority of these bacteria prefer environments without oxygen, although they can tolerate it (known as facultative aerobes).

II. Chemosynthetic autotrophic bacteria :

Bacteria in this group get their energy to make food by breaking down specific inorganic substances such as ammonia, nitrates, nitrites, and ferrous ions. Unlike using light, they don't rely on it for energy. The chemical energy they get is stored in ATP molecules. Later, they use this energy to assimilate carbon, using hydrogen from a source other than water, like hydrogen bacteria, nitrifying bacteria, sulfur bacteria, etc. These bacteria are essential for recycling nutrients like nitrogen, phosphorus, iron, and sulfur. Examples include Nitrosomonas and Nitrococcus.

III. Heterotrophic bacteria

The most common bacteria in nature are heterotrophic bacteria, and many of them play a crucial role in breaking down substances. Unlike some other bacteria, they can't make their own food from basic materials. Instead, they get their nutrition from either dead and decomposing organic matter or directly from a living host. Heterotrophic bacteria are useful in processes like turning milk into curd, producing antibiotics, and helping legume roots fix nitrogen.

Reproduction

Bacteria mostly reproduce through asexual methods, but they can also undergo sexual recombination (although true sexual reproduction is not present).

A. Asexual Reproduction

Bacteria create different kinds of asexual spores such as sporangiospores, oidia, conidia, and endospores. But the most usual way they reproduce without sex is through binary fission.

When conditions are right, with enough nutrients, moisture, and the right temperature, the daughter cells from binary fission can keep dividing and create a large population. Fortunately, this super-fast growth is rare. The process usually slows down and eventually stops due to:

(i) Shortage of space
(ii) Lack of nutrient availability
(iii) Accumulation of waste products (making environmental conditions unfavourable for growth).
(iv) Development of bacteriophages, destroying bacteria.

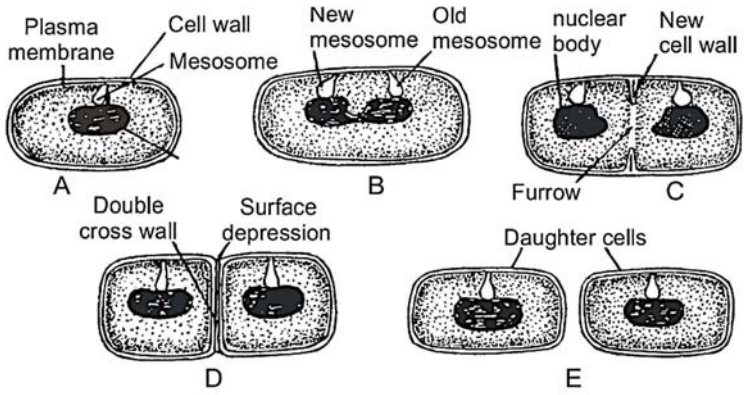
a) Binary Fission

When a fully grown bacterial cell splits, it forms two new cells. This type of cell division is called amitotic, meaning it doesn't use a structure called the spindle during the process.

The binary division of a bacterial cell involves mainly 3 steps:

(i) Replication of DNA

The genetic material in bacteria copies itself, creating two circular chromosomes.



(ii) Mesosome division and membrane formation

The main chromosome in bacteria connects to a structure called the mesosome. The mesosome starts to divide as a membrane forms between the DNA-mesosome connection points. This process pushes each mesosome toward the center of a new cell. Since each mesosome has one chromosome attached to it, this ensures that the two daughter chromosomes are correctly separated into the new cells.

(iii) Cross-wall formation

A rim of the outer cell membrane folds in and keeps growing until the two cells are apart. Materials for the cell wall are added between these membranes, finishing the cell division. The two processes, making the septum and building the cross wall, happen at the same time.

b) Endospores

Some bacteria cells, like those of Bacillus and Clostridium, create tough, resistant structures inside the cell called endospores. Usually, a single bacterial cell produces just one endospore.

B. Sexual Recombination (Genetic Recombination)

Bacteria show a basic type of sexual reproduction that's different from the way eukaryotes do it because they don't form gametes or undergo fusion. Still, the key aspect of sexual reproduction—swapping genetic material—does happen, and it's known as genetic recombination.

Economic Importance

A. Some Useful Bacteria

(i) Soil fertility / biofertilisers
Free-living N_2-fixing bacteria : Azotobacter, Clostridium, Klebsiella, Beijerinckia
Symbiotic N_2-fixing bacteria : Rhizobium, Frankia, Xanthomonas
Ammonifying bacteria : Bacillus vulgaris, B.ramosus

(ii) Vinegar production : Acetobacter aceti

(iii) Curd, cheese, yoghurt production : Lactobacillus, Streptococcus lactis

(iv) Petroleum pollution control : Pseudomonas putida (super bug)

(v) Antibiotics production : e.g.
Bacitracin : Bacillus licheniformis
Subtilin : B. subtilis

(vi) Retting of fibres : e.g., Clostridium perfringens, Pseudomonas fluorescence

(vii) Curing of leaves : To improve the flavour and taste in tea by Micrococcus candidans and in tobacco leaves by Bacillus megatherium

B. Harmful activities :

(i) Vibrio cholerae - Cholera

(ii) Salmonella typhi - Typhoid

(iii) Clostridium tetani - Tetanus

(iv) Xanthomonas citri - Citrus Canker

Archaebacteria

Archaebacteria are most primitive form of life that are found in most extreme environmental conditions like high salt concentration, high temperature etc. These are oldest of the 'living fossils.

They Show Following Features

- The cell wall of archaebacteria is composed of no cellulosic polysaccharides or pseudomurein or glycoproteins / proteins.
- Peptidoglycan and muramic acid are absent in cell wall.
- Plasma membrane has long chain branched lipids (phytanols - glycerol ether lipids). The Latter decrease membrane fluidity and help to increase tolerance against extremes of heat, low pH.
- Their 16 S rRNA genes are different from that of eubacteria.

Types of Archaebacteria

These are of three types

Methanogens

Methanogens are present in the guts of several ruminant animals such as cows and buffaloes and they are responsible for the production of methane (biogas) from the dung of these animals.

Halophiles

They survive in salty water due to presence of branched chain lipids in their cell membrane, absence of sap vacuoles & maintenance of high osmotic concentration.

E.g. Halo bacterium, Halo coccus.

Thermoacidophiles

They are facultative anaerobe, found in hot water springs at temperature as high as 80ºC and pH as low as 2. They tolerate high temperature due to homopolar bonds in their proteins. They oxidize sulphur to H2SO4 under aerobic conditions and pH 2. This acid makes medium acidic. Sulphur is reduced to H2S in anaerobic conditions.

E.g. Thermoplasma, Sulfolobus.

Note All Archaebacteria are Gram negative organisms. Archaebacteria differ from other bacteria in having a different cell wall structure and this feature is responsible for their survival in extreme conditions.

Eubacteria

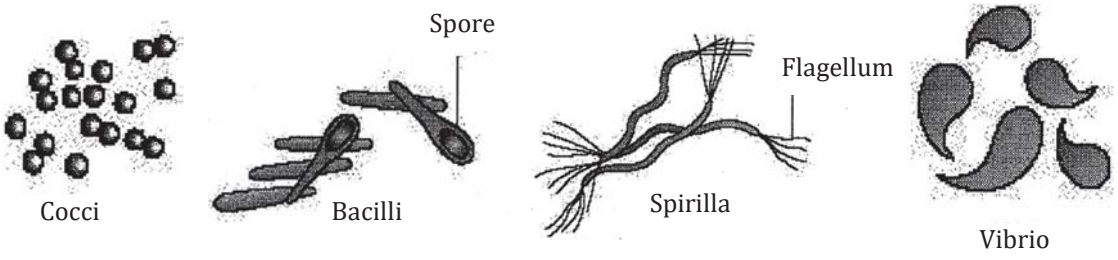
History

- They were first observed in rainy water and later in teeth scum by Leeuwenhoek (1675) and called them "Animalcule".
- F.J. Cohn and Ehrenberg first of all coined the name "Bacteria".
- Bergey placed bacteria in "Prosophyta group" and wrote a book "Manual of Determinative Bacteriology/Microbiology". This book is known as "Bible of bacterial classification".

Shape

On the basis of shape, Cohn (1972) recognised 4 basic forms of Eubacteria.

- Coccus (Pl. Cocci): These are always nonmotile / monoflagellated. Spherical or oval shaped.
- Coccus bacteria can be found in Monococcus, Diplococcus, Streptococcus (chain), Staphylococcus (cluster) and Sarcinae (8-64 cocci).
- Bacillus (Pl. Bacilli): Rod shaped with blunt ends and motile/nonmotile. It is most common shape.
- Spiral (Pl. Spirilla): They are elongated, spiral shaped, flagellated and cork screw like.
  E.g. Spirillum volutans.
- Vibrium (Pl. Vibrio): It looks like sign of comma (,) and slightly curved rod of less than half turn
  E.g. Vibrio cholerae.



Motility in Bacteria

- Bacteria are motile as well as non-motile. Movement in bacteria takes place by means of flagella. On the basis of number and arrangement of flagella (flagellation) bacteria are of following types
- Atrichous - When flagella are absent, it is called Atrichous form
  E.g. Micrococcus
- Monotrichous - When only one flagellum on one end of the bacterium
  E.g. Vibrio
- Amphitrichous - When single flagellum is present on both the ends of bacterium.
  E.g. Nitrosomonas
- Lophotrichous - When a bunch of flagellums is present on both end of bacterium.
  E.g. Salmonella
- Cephalotrichous - When a bunch of flagella is present on one end of bacteria.
  E.g. Corynebacterium
- Peritrichous - When flagella are found on the whole body of bacterium.
  E.g. E. coli. Salmonella typhi

A flagellum of bacteria is made up of three parts:

(1) Basal body (2) Hook (3) Filament

Basal body –

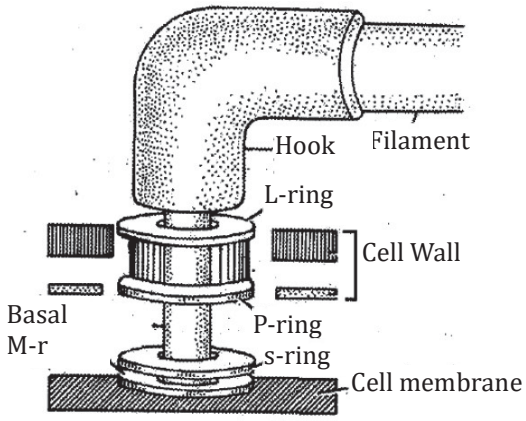
- It is the basal part of flagellum and rod shaped in structure.
- It lies within the cell wall and cell membrane
- This proteinaceous rod shaped structure is surrounded by two pairs of rings
  (i) Outer pair (ii) Inner pair
- Outer pair of ring lies within the cell wall. One ring of this pair is called L and another called P.
- Inner ring of inner pair lies within the cell membrane. One ring of this pair is called S and M.
- In Gram (+) bacteria only one pair of rings (inner pair) is found.

Hook-

- It connects the basal body to filament
- It is the middle part of flagellum
- It's some part lies within the cell wall.

Filament –

- It is cylindrical hollow structure made up of protein monomers.
- Each monomer is made up of flagellant protein. Aagellin is a contractile protein.
- These monomers are arranged spirally in 4 + 4 manner.



Pili

- Bacterial cell wall is covered by numerous hair like structures called pili. Pili are smaller than the flagella. (Pl. - Pili → Sing. - Pilus)
- They are of two types- (A) Longer pili, (B) Shorter pili
- Longer pili is also known as 'F' pili or 'sex' pili. Longer pili occurs in only donor (P or male) bacteria and help in conjugation. These are absent in recipient bacteria or female.
- The shorter pili take part in attachment (to rocks in streams and to the host tissue). These are also known-as 'infective' pili or fimbriae.

Structure-

- Every pilus is cylindrical hollow structure and composed of protein monomers.
- Each monomer is made up of 'pilln' protein. Pilin is non-contractile protein.

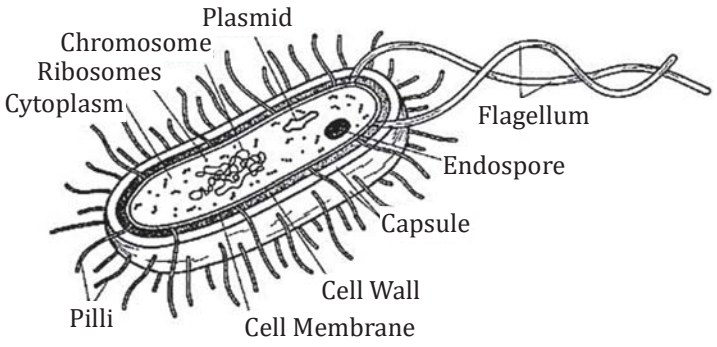
- Pili do not play role in motility.

Structure of Eubacteria

Though the bacterial structure is very simple, they are very complex in behavior bacterial cell has a chemically complex cell envelope. The cell envelope consists of a tightly bound three layered structure.

- Outermost glycocalyx (may be capsule or slime layer)
- Cell wall
- Cell membrane

  Although each layer of the envelope performs distinct function they act together as a single protective unit.



Glycocalyx (Capsule or Slime layer)-

- Loose and thin layer is called slime layer and thick and tough layer is called capsule. Formation of Glycocalyx is done by cell membrane.
- Capsule is made up of polysaccharides and polypeptides while slime layer is made up of mainly polysaccharides.
- Glycocalyx protects the bacteria from W.B.C. and also helps in colony formation.

Cell Wall-

- Bacterial cell wall is rigid and made up of mainly peptidoglycan.
- In Gram (+) bacteria cell wall is single layered and thick. It is made up of peptidoglycan. Lipids are also present but in less quantity.
- While in Gram (-) bacteria cell wall is double layered. Inner layer is thin and composed of peptidoglycan while outer layer is thick and made up of lipopolysaccharide.

L - form - Bacterial cell wall can be dissolved by lysozyme enzyme. When bacterial cell wall is removed artificially by Lysozyme then, bacteria are called L- form (Lister form).

Cell membrane-

- Bacterial cell membrane is made up of lipoprotein like the eukaryotic membrane.

Cytoplasm-

- In bacterial cytoplasm membrane bound cell organelles viz. Mitochondria, Chloroplast, E.R., Lysosome, Golgi body, Micro bodies etc. are absent.
- Bacterial cytoplasm shows no streaming or cyclosis.

Cytoplasmic organelles –

Mesosomes-

The cell membrane of bacteria invaginates (extensions) in cytoplasm at different places and form mesosomes or chondrioid. These extensions are in the form of vesicles. Tubules and lamellae.

Functions of Mesosomes:

- Cell respiration (increases the surface area of the plasma membranes and enzyme content)
- Cell wall secretion.
- DNA replication
- Cell division (distribution of daughter cells).
  Mesosomes functionally mitochondria like structures because respiratory (Oxidative) enzymes are found in mesosome.

Storage granules/Inclusion bodies –

Reserve material in prokaryotic cells are stored in the cytoplasm in the form of inclusion bodies. These are not bounded by any membrane system and lie free in the cytoplasm.

- Glycogen granules- They store carbohydrate
- Volute granules- These are also known as met achromatic granules. The volutin granules are phosphate polymers and function as storage reservoir for phosphate.

Chromatin material (Nucleotide)-

- Nucleus of bacterial cell is called nucleotide or gonophores or incipient nucleus or fibrillar nucleus. Nuclear membrane and nucleolus are absent and DNA is ds circular naked.
- Beside the main DNA another small and ds-circular DNA is also present in bacterial cell, which is called Plasmid. It is also known as extra chromosomal or extra nuclear genetic material. (The term 'plasmid' was given by Lederberg).
- Plasmids have the ability to replicate independently.
  Plasmid are of many types on the basis of their functions and phenotypic characters.
  For fertility factor (F-plasmid):-On the basis of presence or absence of 'F' factor, there are two mating types of bacteria.
- F^+ - Cells, carrying 'F' factor acts as donor and are called f^+ or male.
- F^- - Cells, lacking 'F factor acts as recipient and are called F^- or female.

When 'F" plasmid is attached with main DNA, it is designated as episome and this type of cell is known as Hfr (High frequency recombination) cell.

Staining Of Bacteria

Gram Staining Technique:

- Hans Christian Gram developed this technique to stain bacteria.

Steps of gram staining technique:

Bacteria are firstly stained by weak alkaline solution of crystal violet (Gram stain).

↓

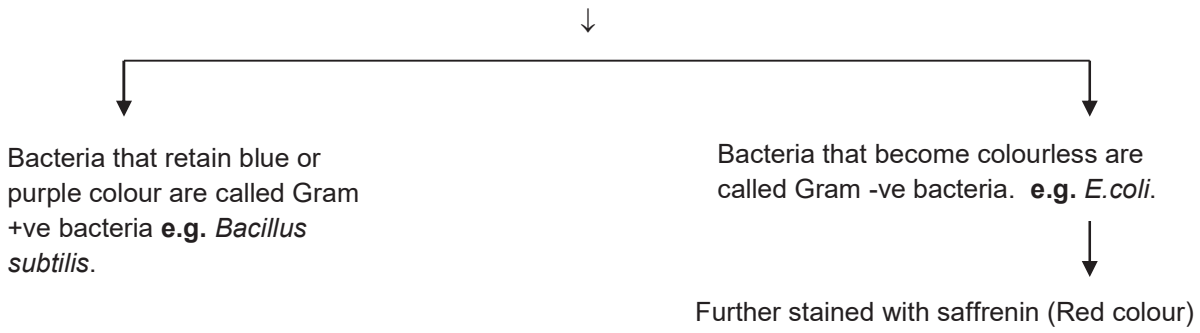
All the bacteria become purple coloured.

↓

Bacteria are treated with 0.5% iodine solution (fixative).

↓

Washed with water and then absolute alcohol or acetone (decoloriser).



Nutrition in Bacteria:

- Bacteria show the most extensive metabolic diversity among all living organisms.
- Most of bacteria are heterotrophs and majority of them are decomposer and some of them are parasitic.

Type of nutrition:

Autotrophic bacteria: These bacteria synthesize their own food by using light (Photoautotrophs) or chemical energy (Chemoautotrophs)

Phototrophs:

- They perform photosynthesis (non-oxygenic)
- Photosynthetic pigment are present in cytoplasm (Chromatophore).
- Hydrogen donor for photosynthesis are generally are inorganic compounds like H_2S, Thiosulphate and some organic compounds.

E.g. Purple sulphur bacteria (Chromatium).
Green sulphur bacteria (Chlorobium, Thiothrix).
Purple non-sulphur bacteria (Rhodospirillium and Rhodopseudomonas).

Chemoautotrophs:

- Chemosynthetic autotrophic bacteria (Ammonifying bacteria, Nitrifying bacteria) oxidise various inorganic substances such as nitrates, nitrites and ammonia and use the released energy for their ATP production. They play a great role in recycling nutrients like nitrogen, phosphorous, iron and sulphur.
- Nitrifying bacteria- They oxidise nitrogenous compounds and obtain energy.

$$NH_3 \xrightarrow{\text{Nitrosomonas or Nitrococcus}} NO_2 \xrightarrow{\text{Nitrobacter}} NO_3$$

Heterotrophs

- Most of the bacteria are heterotrophic i.e. they cannot manufacture their own food.
  The majority of heterotrophic bacteria are important decomposers. They are useful in making curd from milk, Production of antibiotic, fixing nitrogen in legumes. Some are pathogens to human being, animals and plants.
- They receive their own food from dead organic matter or living organism.

These are of following types

Saprotrophic bacteria - These bacteria obtain food from dead and decaying organic matter.

- **Obligate saprotrophic -** These bacteria obtain food only from dead organic matter. These are completely saprotrophs e.g. Bacillus vulgaris, Clostridium botulinum

- **Facultative parasite-** These are normally saprophytic in nature, but in the absence of dead organic matter they can become parasitic. E.g. Pseudomonas, Staphylococcus

Parasitic bacteria - They obtain their food from living organism

- **Obligate parasite -** They always remain parasitic. e.g. Mycobacterium leprae
- **Facultative Saprotrophic -** They are normally parasitic in nature but in the absence of living host, they may become saprotrophs e.g. Mycobacterium tuberculosis

Symbiotic bacteria

These bacteria convert atmospheric nitrogen into nitrogenous compounds like Amino acid, NO_3 or Salts of ammonia. E.g. Rhizobium

Reproduction:

Bacteria reproduce by two methods

(1) Asexual reproduction (2) Genetic recombination

Asexual reproduction

By Binary Fission

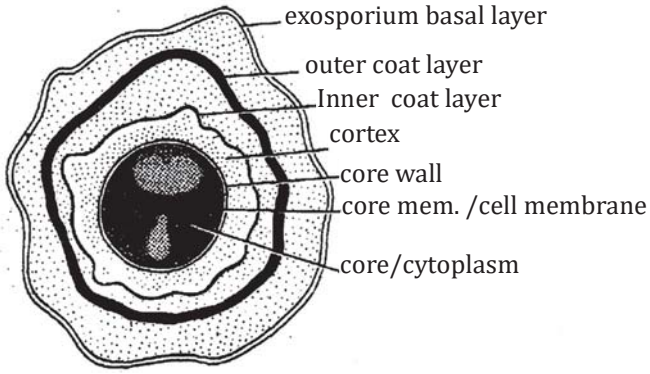
It takes place during favourable conditions. The transverse binary fission is quite common in which nucleoid divides amitotically without spindle formation. Replication of DNA is bidirectional in entire genome resulting two circular θ (theta) shaped chromosomes are formed (Theta model of replication of Cairns).

By Endospore - Endospore formation occurs under unfavorable conditions.

- It is a highly resistant structure. It is resistant to temperature, radiations, antibiotics and chemicals.
- Endospore is highly resistant structure due to presence of Ca-dipicolinate in cortex.
- Endopspore formation is seen in mostly bacillus type bacteria.

Differences between Gram positive and Gram negative Bacteria

	Gram positive	Gram negative
1.	The bacteria remain purple coloured with Gram staining even after washing with alcohol.	The bacteria do not retain the stain when washed with alcohol.
2.	Cell wall is single layered.	Cell wall is bilayered.
3.	Cell wall of peptidoglycan is 20-80 nm. Thick.	Cell wall of peptidoglycan is 8-12 nm. Thick.
4.	Murein (Peptidoglycan) content is 70-80%.	Murein (Peptidoglycan) content is 10-20%.
5.	The wall is smooth.	Wall is wavy and comes in contact with cell membrane only at a few loci.
6.	Basal body of the flagellum contains 2 rings (S & M).	Basal body of the flagellum has 4 rings (L, P, S & M).
7.	Mesosomes are quite prominent.	Mesosomes are less prominent.
8.	A few pathogenic bacteria belong to Gram-positive group.	Most of the pathogenic bacteria belong to Gram-negative group.
9.	Teichoic acid present in cell wall	Teichoic acid absent



Genetic Recombination –

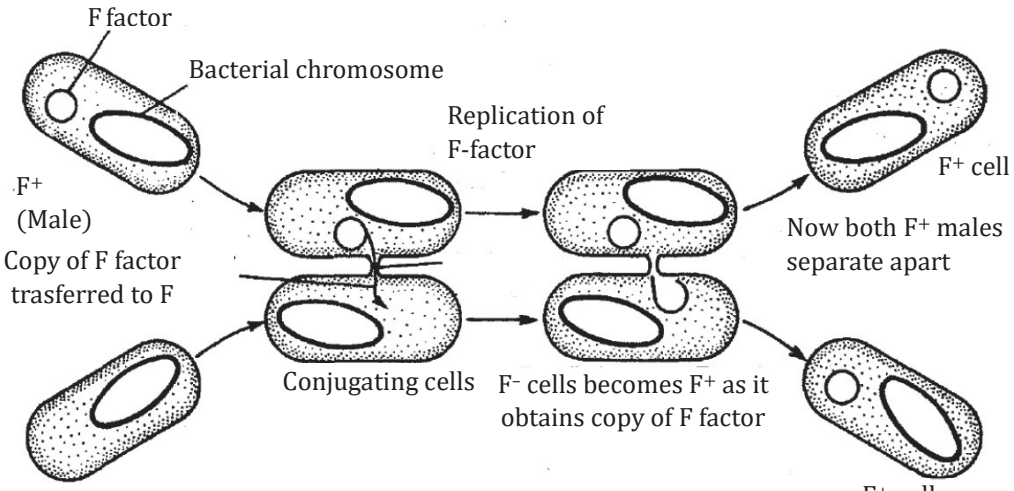
Genetic Recombination includes three methods:

(1) Transformation (2) Transduction (3) Conjugation

Conjugation (between F^+ and $F^- \Rightarrow$ (Sort of sexual reproduction)

Conjugation was first discovered in 1946 by Lederberg and Tatum in E. coli.

- First of all donor cell (f^+) is attached to recipient cell (F^-) with the help of sex pili. Sex pili functions as conjugation tube.
- The 'F' factor (F plasmid) now replicates and the replica moves to F^- through conjugation tube.
- Both the cells are then separated. Due to transfer of 'F' factor F^- bacteria now becomes f^+ bacteria.



GENETIC RECOMBINATION THROUGH CONJUGATION

Respiration

On the basis of respiration bacteria are of two types

Aerobic bacteria

- **Obligate aerobic -** These are completely aerobic and die in the absence of O_2. Eg. Azotobacter
- **Facultative anaerobic-** These are normally aerobic bacteria but can survive in the absence of O_2 eg. Acetobacter aceti (it causes souring of wine), Clostridium tetani

Anaerobic bacteria

- **Obligate anaerobic -** These are completely anaerobic bacteria and do not have capacity of aerobic respiration.
  Eg. Clostridium botulinum
- **Facultative aerobic -** These are normally anaerobic but also have capacity of aerobic respiration.
  Eg. Fermentation bacteria (Lactobacillus) except Acetobacter aceti Lactobacillus causes souring of milk.

Economic importance of bacteria

Harmful activities

Bacterial diseases in human		
S.No.	**Disease**	**Bacteria**
1	Typhoid	Salmonella typhi
2	Tetanus	Clostridium tetani
3	Cholera	Vibrio cholerae
4	Tuberculosis (TB)	Mycobacterium tuberculosis
5	Anthrax	Bacillus anthracis
6	Leprosy (Hansen's disease)	Mycobacterium leprae
7	Diphtheria	Corynebacterium diphteriae
8	Meningitis	Neisseria meningitides
9	Plague (Black death)	Yersinia (Pasteur Ella) Pestis
10	Botulism (Food poisoning)	Clostridium botulinum
11	Syphilis (STD)	Treponema pallidum
12	Pneumonia	Streptococcus pneumoniae
13	Pimples	Staphylococcus aureus

Bacterial diseases in plants		
S.No.	**Plant diseases**	**Causal organism**
1	Red stripe of sugarcane	Pseudomonas rubrilineans
2	Citus canker	Xanthomonas citri
3	Crown gall	Agrobacterium tumefaciens
4	Bacterial blight of rice	Xanthomonas oryzae
5	Black rot of cabbage	Xanthomonas campestris
6	Tundu (Bacterial rot) of wheat	Corynebacterium tritici

Denitrification - Denitrifying bacteria –

- Some bacteria convert soil nitrates into nitrites and then nitrogen. These bacteria reduce the fertility of soil. E.g. Thiobacillus denitrificans, Pseudomonas denitrificans

Food poisoning-

- Botulism- Clostridium botulinum-It is most lethal type of food poisoing. These bacteria survive in absence of 0 2.These bacteria multiply in canned food. Their toxins damage the parasympathetic nervous system. It leads to paralysis of both smooth and striped muscles, resulting in immediate death.

Water pollution-

- Several bacterial forms cause water pollution. These bacteria spoil the water. E.g. Vibrio cholerae, Salmonella typhi.

Biological Weapons –

- Some bacteria are used as bio weapons such as Anthrax causing, Botulism, Cholera causing bacteria.

Userly Activities

Ammonification - Ammonifying bacteria -

Some bacteria convert Protein (present in decaying plants & animals) into Ammonia. e.g., Bacillus vulgaris

Nitrification - Nitrifying bacteria –

These bacteria convert Ammonia in to Nitrite and later into Nitrate.

$$NH_3 \xrightarrow{\text{Nitrosomonas}} NO_2\,(\text{Nitrite}) \xrightarrow{\text{Nitrobacter}} NO_3\,(\text{Nitrite})$$

Nitrogen fixation - Nitrogen fixing bacteria –

These bacteria convert the atmospheric nitrogen into nitrogenous compounds like amino acids, nitrate or ammonium salts.

Nitrogen fixation is done by two methods –

Symbiotically- Some bacteria live symbiotically and do nitrogen fixation. e.g.

- Rhizobium - found in the root nodules of legumes
- Azorhizobium -found in the stem nodules of Sesbania plant
- Azospirillum-Found on root surface of cereals i.e., superficial symbiosis (eg. Wheat, Rice, Maize).
- Frankia (Filamentous bacteria or actinomycetes) -It is found in root nodules of non-leguminous plant Casuarina and Alnus plants.

A symbiotically - Some bacteria are found freely in soil and do nitrogen fixation. E.g. Clostridium, Chromatium, Azotobacter, Azospirillum, Beijernickia Rhodomicrobium, RhodospiriUum, Rhodopseudomonas

Note: Azotobacter and Beijemickia are aerobic Rhodospirillum is anaerobic bacteria. Both Rhizobium and Frankia are free living in son, but as symbionts, can fix atmospheric nitrogen.

Dairy products –

Dairy products are formed with the help of bacterial fermentation.

$$\text{Milk} \xrightarrow[\text{Lactobacilluslactis}]{\text{Streptococuslactis or}} \text{Curd}$$

Note: Lactobacillus lactis (LAB/Lactic acid bacteria) increase vitamin B_{12} in curd LAB also help in checking the disease causing microbes in stomach.

Antibiotics -

- For example streptomycin is obtained from Streptomyces griseus (It is an actinomycetes)
- Term antibiotic was given by S.A. Waksman

- First discovered antibiotic was Penicillin it was obtained from fungi Penicillium.
- First discovered antibiotic from bacteria was streptomycin.
- Many antibiotic medicines are obtained from the bacteria.
- Some substances produced by microorganism which inhibit the growth of other micro-organism are called antibiotic substances.

Industries –

Many bacteria are used in industries

- Vinegar formation (Acetic acid) -

$$\text{Ethanol} \xrightarrow{\text{Acrobacter aceti}} \text{Acetic acid}$$

- Retting of fibres - Separation of fibres from plants by the help of bacteria
  E.g. Clostridium, Butyric acid bacteria
- Flavoring /curing of tea leaves and processing of tobacco leaves-
  E.g. Bacillus megatherium, Micrococcus condiscence

Production of Vitamins-

- Clostridium butylicum produces → Riboflavin (Vit. B_2) and Butyric acid
- Propionibacterium and Bacillus megatherium produce- Vit. B_{12}
- E.coli (coliforrn bacteria) produces → Vit. E., Vit. K.
- E. coli bacteria found in alimentary canal of human beings.

Purity of Ganga water

In Gangatic water a bacteria Bdellovibrio bacteriovorus is found, they kill the other water polluting bacteria.

Pollution indicating bacteria:-

Water in which E. coli bacteria are present known as polluted water. Quality of water depends on number of E. coli. If E. coli are very much in no the water will be highly polluted. So the E. coli is known as pollution indicating bacteria.

Bacteria for genetic engineering - Eg. E. coli and Agro bacterium → These are Gram (-) bacteria

Blue Green Algae (Cyanobacteria):

General character

- They are aerobic photoautotrophic, nitrogen fixing Gram negative prokaryotes included into separate class Cyanophyceae or Myxophyceae. They evolved in Precambrian period around 3.2 billion years ago.
- They are found in all types of habitats - fresh water (mostly), marine water & terrestrial.

Note:

Oscillotoria brevis can survivive in hot water sulpher springs at a temperature of 70o-80o C due to homopolar bonds in their protein.

Trichodesmium erythrium grow in Red sea and responsible for Red colour of Red sea.

They can be –

Unicellular–e.g. Spirulina;

Colonial–e.g. Gloeocapsa, Microcystis;

Filamentous – e.g. Anabaena, Nostoc, Oscillatoria.

- The colony are generally surrounded by gelatinous/Mucilaginous sheath (Made up of Mucopolysaccharide).
- Thylakoids are unilamellated, have chl a, β carotenes and xanthophyll and three types of phycobilin pigments c-phycocyanin, c- phycoerythrin and allophycocyanin.
- Reserve food material is mainly cyanophycean starch (Structure is similar to glycogen). Proteinaceous granules, β granules (Fat droplet) are also found in some forms.
- They were first to oxygenic photosynthesis to evolve O2 in photosynthesis.
- BGA is able to fix atmospheric nitrogen in to ammonium compounds. For this purpose some of their cells become pale yellow and thick walled structure called heterocysts. The latter has nitrogenase enzyme that performs nitrogen fixation in anaerobic conditions e.g. Anabaena, Nostoc, Aulosira.
- Its cell wall consists of peptidoglycan (inner layer) and lipopolysaccharides (outer layer).

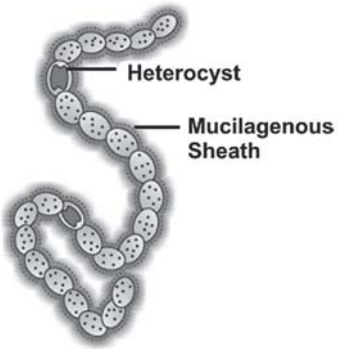


Fig. A filamentous blue -green algae - Nostoc

- Sterol is absent in cell membrane and the latter contains protein and phospholipid in 2:1 ratio.
- Protoplast of cell is differentiated into outer peripheral coloured chromoplasm and central colourless region centroplasm.
- The chromoplasm has photosynthetic lamellae or thylakoids, 70 S ribosomes.

- Lamellasome connects nucleoid to cell membrane and help in respiratory activities, septum formation and separation of replicated DNA.
- Nitrogen filled gas vacuoles are found instead of sap vacuoles and they help in buoyancy and protection from UV rays.
- Definite nucleus and definite plastid with grana are absent. Flagella, mesosome, chlorophyll b, meiosis, and all membrane bounded organelle are absent.

Reproduction in BGA

- Sexual reproduction is absent in BGA but gene recombination occurs by conjugation, transformation, and transduction.

Vegetative reproduction:

- **Unicellular forms:** Binary fission. It is the most common method of reproduction in BGA.
- **Filamentous forms:** Fragmentation and Hormogonia (short segments of the filament that form new filament after separation in the region of heterocysts).
- **Asexual reproduction:** Take place by Akinetes formation. Akinetes are formed under unfavourable conditions.

Economic Importance of BGA:

- BGA can fix atmospheric nitrogen e.g. Aulosira fertilissima is most active nitrogen fixer in rice fields enriching (up to 20%) rice fields with nitrogen, Anabaena azollae is found in the leaves of Azolla (an aquatic fern) and fix nitrogen hence Azolla is introduced in rice fields as bio fertilizer. Nostoc, Tolypothrix, Cylindrospermum, are other major nitrogen fixers.
- Spirulina maxima is rich in protein (71%) and vitamins. It is used as Single Cell Protein (SCP) for human consumption, poultry, fisheries and feeding for cattle's.
- Nitrogen fixing BGA like Nostoc, Anabaena are used as a green manure that help in retaining soil moisture along with supply of nitrogen salts.
- Excessive growth of blue green algae (like Microcystis) is responsible for the formation of Algal bloom in NO3 and PO4 rich water and cause deficiency of oxygen in water that is responsible for death of fishes.
- Colonies of Nostoc (called Yuyucho) are consumed as food in China.
- Cyanobacteria reduce soil acidity.

Mycoplasma

- In 1898, two French scientists E. No card and R. Roux while studying pleural fluids of cattle suffering from pleuropneumonia disease, discovered the organisms which are known as mycoplasma and were designated as PPLO (i.e. Pleuropneumonia like organism).
- Nowak (1929) put these organisms under the genus Mycoplasma.
- The Japanese Doi et.al. (1967) first discovered that the "Aster yellow" diseases of plants are caused by Mycoplasma. Doi et.al. Named these pleomorphic organisms as mycoplasma like organisms (MLO). According to Doi, phloem cells (Sieve tube & phloem parenchyma) of plants are much affected by this disease.

Mains Points:-

- Mycoplasmas are unicellular, smallest prokaryotic organisms.
- Cell membrane is tri-layered and made up of lipoprotein. Both DNA (ds DNA circular mainly) and RNA (ssRNA) are present.

- They are cell wall less hence, they exhibit pleomorphism and thus called as Joker of microbiology or plant kingdom.
- Osmotrophic mode of nutrition (absorption of nutrients by osmosis) is found in Mycoplasra.
- They are resistant to antibiotics like penicillin which act on cell wall.
- They are sensitive to tetracycline & chloramphenicol that act on metabolic activities.
- Most of the species of Mycoplasma are facultative anaerobs. (Mycoplasma can survive without oxygen)
- Species of Mycoplasma are saprophyte or facultative parasite. Reproduction
- Binary fission: Most common method of reproduction in Mycoplasma..
- By primary structures or "Elementary bodies"

Plant disease

- Little leaf disease of Brinjal
- Bunchy top of papaya.
- Witches broom of Ground nut (Legume) I Potato.
- Aster yellow disease of sunflower.

Note: In plants, mycoplasmal diseases are usually transmitted by leaf hopper.