BIOLOGICAL CLASSIFICATION
KINGDOM MONERA

KINGDOM MONERA (PROKARYOTES)

Introduction:

- **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 PROKARYOTES :-

(1) Cell wall :-

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

(2) Cell membrane :-

(a) Like eukaryotes the cell membrane of prokaryotes is made up of lipoprotein [lipid + protein]

(b) 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.

(3) Cytoplasm :-

(a) The cytoplasm of prokaryotes lacks membrane bound cell organelles.

(b) 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.

(c) In prokaryotes ribosomes are of 70s type. Ribosome's are the site of protein synthesis.

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 :

1. The **cell wall** of archaebacteria is composed of **noncellulosic polysaccharides or pseudomurein or glycoproteins / proteins**.
   - **Peptidoglycan and muramic acid** are absent in cell wall.
2. 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.**
3. 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. (AIPMT 2015)

Halophiles:

- They survive in **salty water** due to **presence of branched chain lipids in their cell mambrane**, absence of sap vacuoles & maintenance of high osmotic concentration. **e.g. Halobacterium, Halococcus**.

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 H_2SO_4 under aerobic conditions and pH 2. This acid makes medium acidic. Sulphur is reduced to H_2S 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

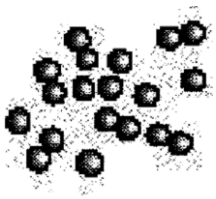
HISTORY

1. They were first observed in rainy water and later in teeth scum by Leeuwenhoek (1675) and called them "Animalcule".
2. F.J. Cohn and Ehrenberg first of all coined the name "Bacteria".
3. 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.

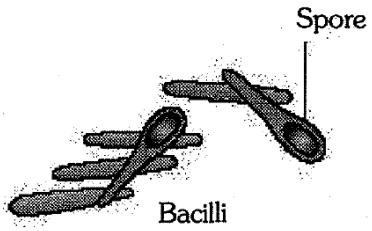
Coccus (Pl. Cocci): These are always nomotile / nonflagellated. Spherical or oval shaped.



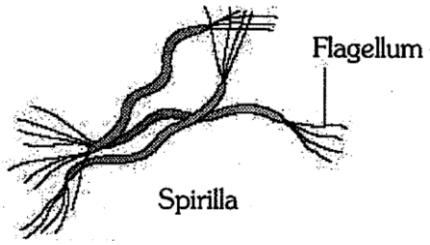
Cocci

Coccus bacteria can be found in Monococcus, Diplococcus, Streptococcus (chain), Staphylococcus (cluster) and Sarcinae (8-64 cocci).

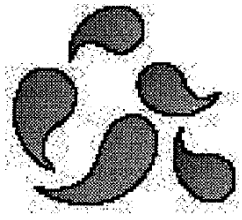
4. **Bacillus (Pl. Bacilli):** Rod shaped with blunt ends and motile/nonmotile. **It is most common shape.**



5. **Spiral (Pl. Spirilla):** They are elongated, spiral shaped, flagellated and cork screw like. **e.g.** Spirillum volutans.



6. **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

1. **Atrichous -** When flagella are absent, it is called atrichous form e.g. Micrococcus
2. **Monotrichous -** When only one flagellum on one end of the bacterium e.g. Vibrio
3. **Amphitrichous -** When single flagellum is present on both the ends of bacterium. e.g. Nitrosomonas
4. **Lophotrichous -** When a bunch of flagellum is present on both end of bacterium. e.g. Salmonella
5. **Cephalotrichous -** When a bunch of flagella is present on one end of bacteria. e.g. Corynebacterium
6. **Peritrichous -** When flagella are found on the whole body of bacterium e.g. E.coli., Salmonella typhi

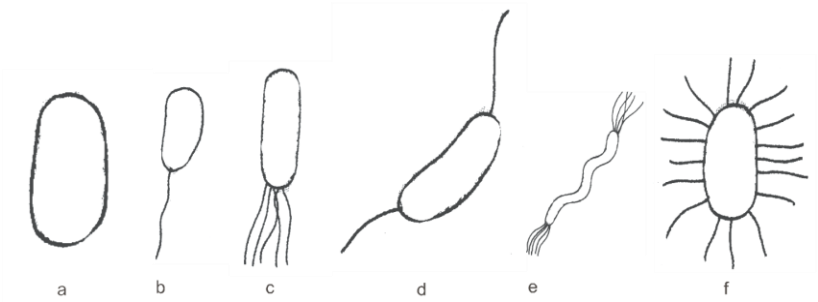


Fig: Flagellation in bacteria

STRUCTURE OF FLAGELLA

A flagellum of bacteria is made up of three parts :

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

1. Basal body –

A. It is the basal part of flagellum and rod shaped in structure.
B. It lies with in the cell wall and cell membrane
C. This proteinaceous rod shaped structure is surrounded by two pairs of rings

(i) Outer pair (ii) Inner pair

D. Outer pair of ring lies with in the cell wall. One ring of this pair is called Land the another called P.

E. Inner ring of inner pair lies with in the cell membrane. One ring of this pair is called S and the another is M.

F. In Gram (+) bacteria only one pair of rings (inner pair) is found.

2. Hook-

A. It connects the basal body to filament

B. It is the middle part of flagellum

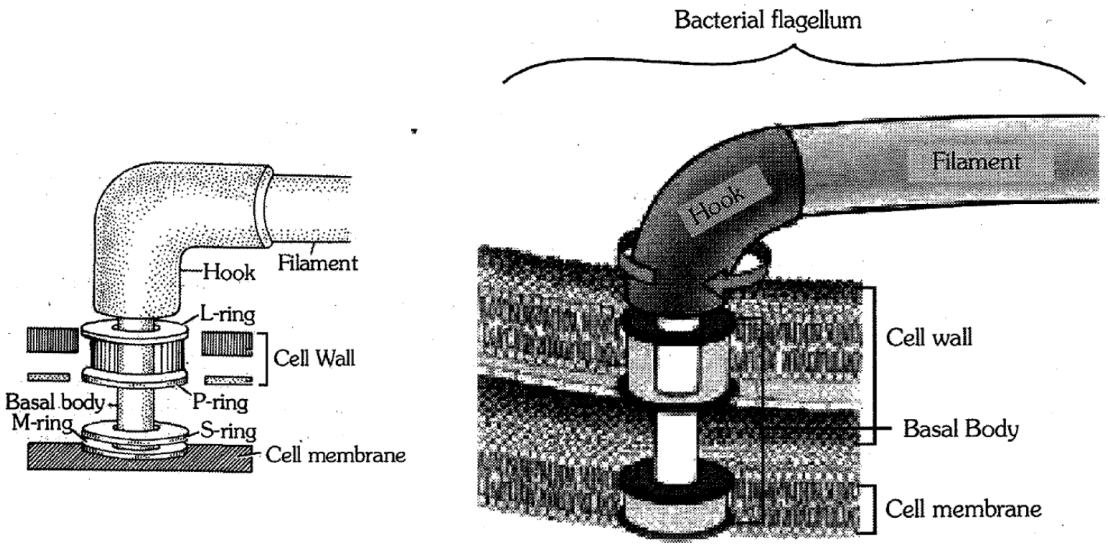
C. It's some part lies with in the cell wall.

3. Filament –

A. It is cylindrical hollow structure made up of protein monomers.

B. Each monomer is made up of ftagellin protein. Aagellin is a contractile protein.

C. These monomers are arranged spirally in 4 + 4 manner.



PILI

1. Bacterial cell wall is covered by numerous hair like structures called pili. Pili are smaller than the flagella.

(Pl.- Pili → Sing. - Pilus)

2. They are of two types- (A) Longer pili, (B) Shorter pili
3. 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.
4. 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-

1. Every pilus is cylindrical hollow structure and composed of protein monomers.
2. Each monomer is made up of 'pilln' protein. Pilin is non-contractile protein.
3. Pili do not play role in motility

STRUCTURE OF EUBACTERIA

Though the bacterial structure is very simple, they are very complex in behaviour

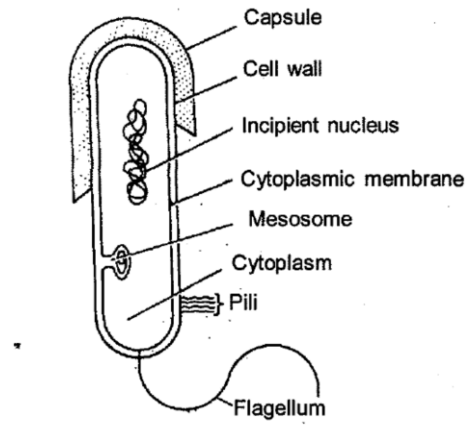
Bacterial cell has a chemically complex cell envelope. The cell envelope consists of a tightly bound three layered structure.

(1) Outermost glycocalyx (may be capsule or slime layer)

(2) Cell wall

(3) Cell membrane

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



STRUCTURE OF A EUBACTERIAL CELL

1. **Glycocalyx (Capsule or Slime layer)-**

A. Loose and thin layer is called slime layer and thick and tough layer is called capsule. Formation of Glycocalyx is done by cell membrane.

B. Capsule is made up of polysaccharides and polypeptides while slime layer is made up of mainly polysaccharides.

C. Glycocalyx protects the bacteria from W.B.C. and also helps in colony formation.

2. **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).

3. **Cell membrane-**

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

4. **Cytoplasm-**

A. In bacterial cytoplasm membrane bound cell organelles viz. Mitochondria, Chloroplast, E.R., Lysosome, Golgibody, Microbodies etc. are absent.

B. Bacterial cytoplasm shows no streaming or cyclosis.

Cytoplasmic organelles -

1. **Mesosomes-**

A. 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 ofMesosomes :

(i) Cell respiration (increases the surface area of the plasma membranes and enzyme content)

(ii) Cell wall secretion.

(iii) DNA replication

(iv) Cell division (distribution of daughter cells).

B. Mesosomes functionally mitochondria like structures because respiratory (Oxidative) enzymes are found in mesosome.

2. **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.

a. Glycogen granules- They store carbohydrate

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

3. **Chromatin material (Nucleotide)-**

A. 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.

B. 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 extranuclear genetic material. (The term 'plasmid' was given by Lederberg).
C. Plasmids have the ability to replicate independently.

Plasmid are of many types on the basis of their functions and phenotypic characters.

(1) For fertility factor (F-plasmid) :-On the basis of presence or absence of 'F' factor, there are two mating types of bacteria.
(a) F^+ - Cells, carrying 'F' factor acts as donor and are called f^+ or male.
(b) 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.

(1) R-Factor - Resistance to antibiotics.

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).

↓

Bacteria that retain blue or purple colour are called Gram +ve bacteria **e.g.** *Bacillus subtilis*.

Bacteria that become colourless are called Gram -ve bacteria. **e.g.** *E.coli*.

↓

Further stained with saffrenin (Red colour)

Nutrition in bacteria:

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

Type of nutrition:

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

a. **Photoautrophs:**

- 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).

b. **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 can not manufacture their own food. The majority of heterotophic 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

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

These are of two types

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

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

2. **Parasitic bacteria -** They obtain their food from living organism

These are of two types

(a) **Obligate parasite -** They always remain parasitic. e.g. Mycobacterium leprae

(b) **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

(1) Asexual reproduction

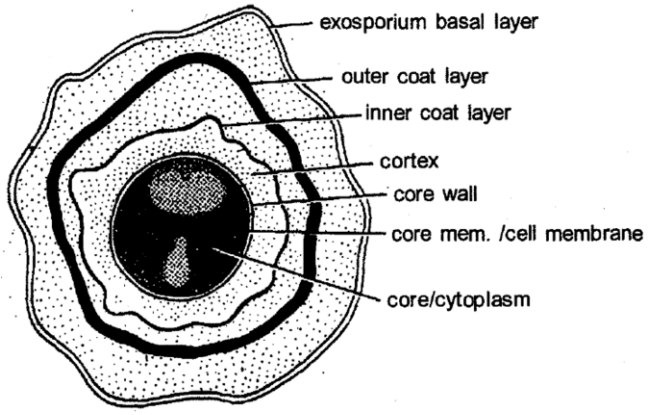
By Binary Fission: It takes place during favourable conditions. The transverse binary fission is quite common in which nucleoid divides amitotically without spindle formation. Replication of DNA is bidirectional in entire genome resulting two circular **θ (theta) shaped chromosomes are formed (Theta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

(i) By Endospore - Endospore formation occurs under unfavourable conditions.

(a) It is a highly resistant structure. It is resistant to temperature, radiations, antibiotics and chemicals.
(b) Endospore is highly resistant structure due to presence of Ca-dipicolinate in cortex.
(c) 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



(2) Genetic Recombination –

Genetic Recombination includes three methods :

(I) Transformation (II) Transduction (III) Conjugation

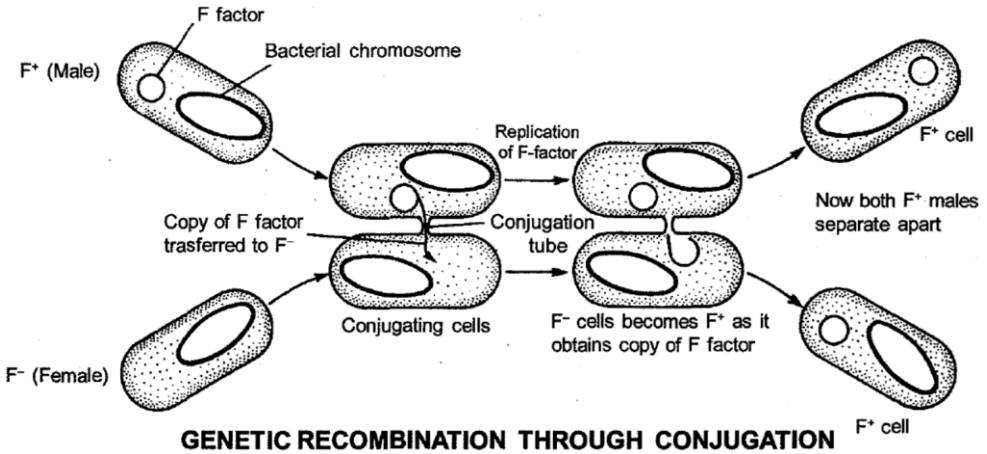
- Conjugation (between F^+ and $F^- \Rightarrow$ (Sort of sexual reproduction)

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

(a) First of all donor cell (f^+) is attached to recipient cell (F^-) with the help of sex pili. Sex pili functions as conjugation tube.

(b) The 'F' factor (F plasmid) now replicates and the replica moves to F^- through conjugation tube.

(c) 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

1. Aerobic bacteria

These are of two types

(A) Obligate aerobic - These are completely aerobic and die in the absence of O_2. eg. Azotobacter

(B) 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

2. Anaerobic bacteria

These are of two types.

(A) Obligate anaerobic - These are completely anaerobic bacteria and do not have capacity of aerobic respiration.

eg. Clostridium botulinum

(B) 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)**	***Mycobactertium tuherculosis***
5	Anthrax	*Bacillus anthracis*
6	Leprosy (Hansen's disease)	*Mycobacterium leprae*
7	Diphtheria	*Corynebacterium diphteriae*
8	Meningitis	*Neisseria meningitidis*

9	Plague (Black death)	*Yersinia (=Pasteurella) Pestis*
10	Botulism (Food poisoning)	*Clostridium botulinum*
11	Syphilis (STD)	*Treponema pallidum*
13	Pneumonia	*Streptococcus pneumoniae*
14	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*

3. 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

4. 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.

5. Water pollution-

Several bacterial forms cause water pollution. These bacteria spoil the water.

e.g. Vibrio cholerae, Salmonella typhi.

6. **Biological Weapons –**

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

USERJL ACTIVITIES

1. Ammonification - Ammonifying bacteria -

Some bacteria convert Protein (present in decaying plants & animals) into Ammonia.

e.g., Bacillus vulgaris

2. Nitrification - Nitrifying bacteria –

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

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

3. 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 –

(A) 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.

(B) Asymbiotically - 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.

4. Dairy products -

Dairy products are formed with the help of bacterial fermentation.

$$\text{Milk} \xrightarrow[\text{Lactobacillus lactis}]{\text{Streptococcus lactis or}} \text{Curd}$$

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

5. 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.

6. Industries -

Many bacteria are used in industries

(A) Vinegar formation (Acetic acid) -

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

(B) Retting of fibres - Separation of fibres from plants by the help of bacteria
e.g. Clostridium, Butyric acid bacteria

(C) Flavoring /curing of tea leaves and processing of tobacco leaves-

e.g. Bacillus megatherium, Micrococcus condiscence

(D) 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.

7. **Purity of Ganga water -** In Gangatic water a bacteria Bdellovibrio bacteriovorus is found, they kill the other water polluting bacteria.

8. **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.

9. **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:

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

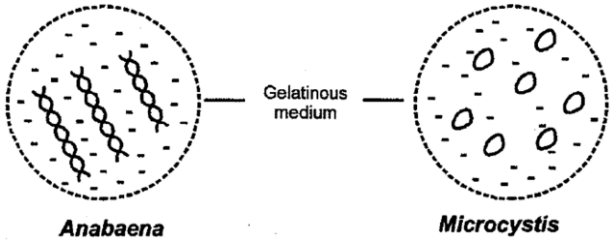
(b) **Trichodesmium erythrium** grow in Red sea and responsible for Red colour of Red sea.

- They can be –

1. **unicellular**–e.g. Spirulina;

eg. *Spirulina*

2. **colonial**–e.g. Gloeocapsa, Microcystis;



3. **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 O_2 in photosynthesis.**
- BGA is able to fix atmospheric nitrogen in to ammonium compounds. For this purspose 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).

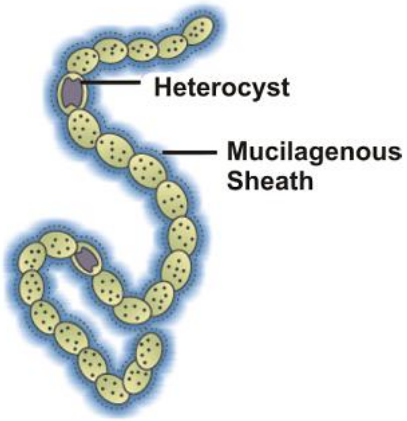


Fig. A filamentous blue -green algae - Nostoc

- **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:**

(a) **Unicellular forms:** Binary fission. It is the most common method of reproduction in BGA.

(b) **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:

(i) **BGA** can **fix atmospheric nitrogen e.g. Aulosira fertilissima is most active nitrogen fixer in rice fields enriching (upto 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 biofertilizer. Nostoc, Tolypothrix, Cylindrospermum, are other major nitrogen fixers.**

(ii) **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 cattles.

(iii) Nitrogen fixing BGA like Nostoc, Anabaena are used as a **green manure** that help in retaining soil moisture along with supply of nitrogen salts.

(iv) Excessive growth of blue green algae (like Microcystis) is responsible for the formation of **Algal bloom** in **NO_3 and PO_4 rich water** and cause deficiency of oxygen in water that is responsible for death of fishes.

(v) **Colonies of Nostoc (called Yuyucho)** are consumed as food in China.

(vi) **Cynobacteria** 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 Japaneese 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 :-

1. Mycoplasmas are unicellular, smallest prokaryotic organisms.
2. Cell membrane is tri-layered and made up of lipoprotein. Both DNA (ds DNA ciruclar mainly) and RNA (ssRNA) are present.
3. They are cell wall less hence, they exhibit pleomorphism and thus called as Joker of microbiology or plant kingdom.
4. Osmotrophic mode of nutrition (absorption of nutrients by osmosis) is found in Mycoplasra.
5. They are resistant to antibiotics like penicillin which act on cell wall.
6. They are sensitive to tetracycline & chloramphenicol that act on metabolic activities.
7. Most of the species of Mycoplasma are facultative anaerobs. (Mycoplasma can survive without oxygen)
8. Species of Mycoplasma are saprophyte or facultative parasite.

Reproduction

1. Binary fission: Most common method of reproduction in Mycoplasma ..
2. By primary structures or "Elementary bodies"

Piant disease

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

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