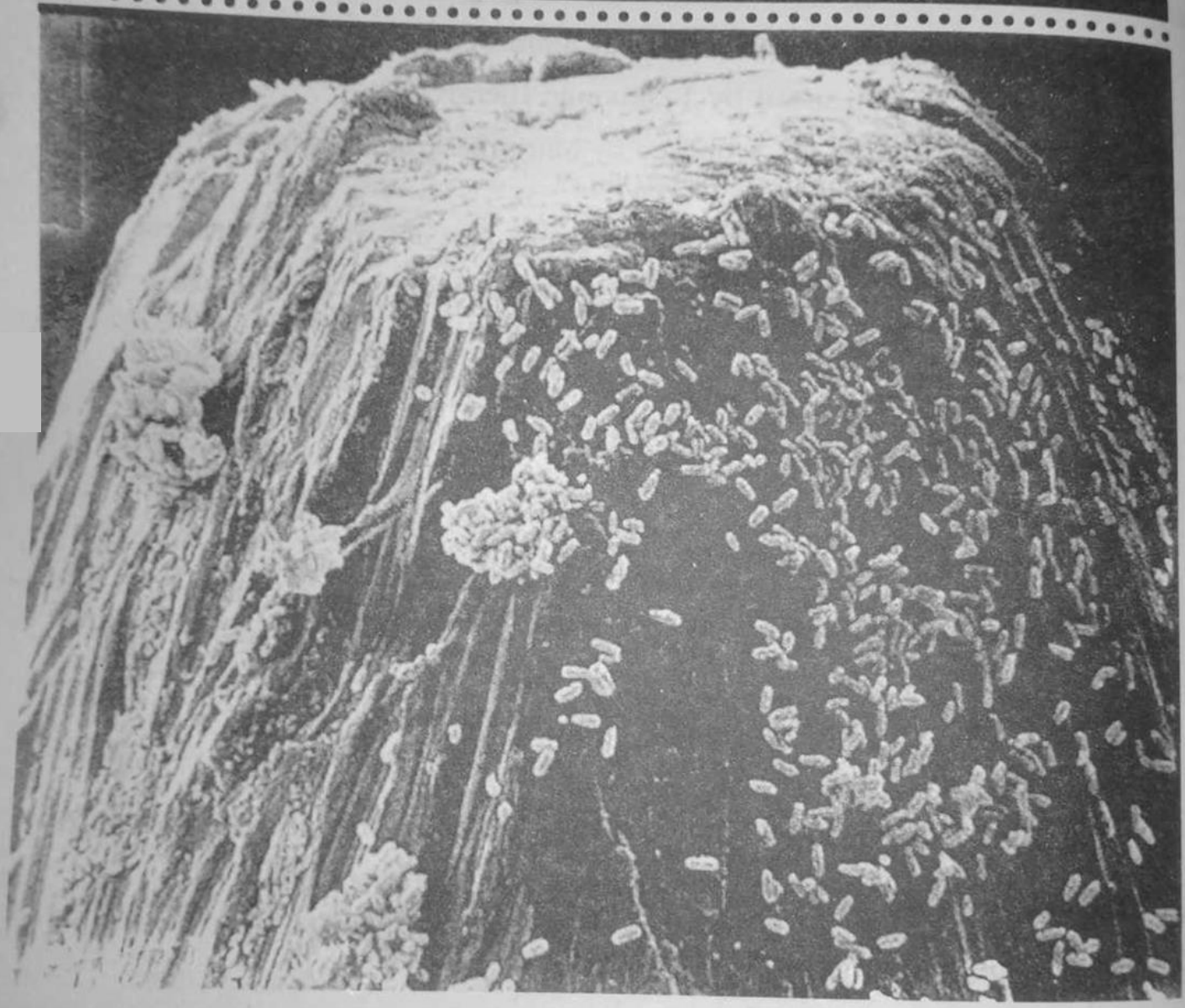
CHAPTER 6

# THE KINGDOM PROKARYOTAE (MONERA)



Prokaryotes were the earliest organisms and they lived and evolved all alone on Earth for 2 billion years. They have continued to adapt and flourish on an evolving Earth and in turn they have helped to change the Earth. In this chapter you will become more familiar with prokaryotes by studying their structure and function, their origins and evolution, their diversity and their ecological significance.

Prokaryotae is a group of living organisms which are unicellular having prokaryotic or a primitive nucleus. Prokaryotes are unicellular organisms, called bacteria, in which each cell contains a single DNA molecule coiled in a loop and not enclosed in a nucleus. They are almost everywhere, indispensable links in the recycling of chemical elements in ecosystem and human use them in research and technology.

## 6.1 BACTERIA

### 6.1.1 Discovery:

Advances in our understanding of living things often depend on the invention of special Instruments. Because of their extremely small size, viruses could not be detected by the optical microscope. Their presence was assumed, however from evidence of their effects on living tissue. The electron microscope later confirmed their existence. It was not so with bacteria. Before the invention of the optical microscope, men lived in ignorance of the presence of these micro organisms.

***Antony Van Leeuwenhoek*** (1673), was the first to observe micro organisms. He constructed a simple microscope and observed a drop of water.

Leeuwenhoek discovered life in a form that was unexpected. He was amazed at the variety of tiny living objects that he saw wriggling and darting across the field of his little microscope when he examined drops of various kinds of water or liquid.

He became so enthusiastic about what he saw that he wrote several letters to the Royal Society in London. One letter with an account of what he saw was published by the Society in 1677. This article included the very first description of bacteria.

### 6.1.2 Structure:

Bacteria are considered as the smallest and the simplest living organisms. Bacterial cell measures from 0.2 micron (μ) to 2 μ in breadth and 2 to 10 μ in length. Bacteria are the pioneers of cellular organization and strictly ***unicellular***. However the cells of some species may remain associated after cell-division and form colonies (Fig. 6.1).

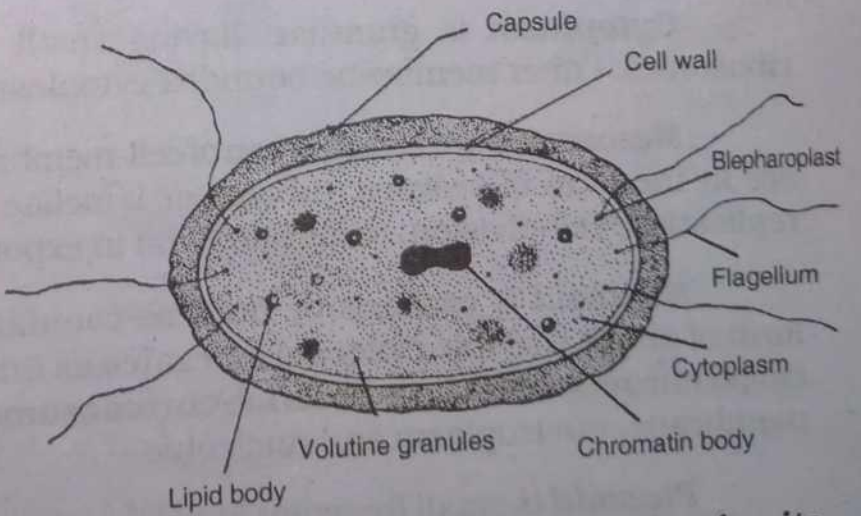



***Fig. 6.1 Diagram of a bacterium showing its internal structure.***

A generalized bacterial cell consists of flagella, pilli, capsule, cell-wall, cell-membrane, cytoplasm, nucleoid, plasmids, mesomes and storage bodies.

**Flagella:** They are extremely thin appendages. They originate from Basal-body, a structure in the cytoplasm beneath cell-membrane. They come out from cell-wall. They are made up of flagellin protien with no microtubules. Flagella help in motility.

**Pili:** They are hollow, filamentous appendages smaller than flagella. They help in conjugation and not in locomotion.

**Capsule:** It is a protective shield made up of polysaccharide and proteins. Some bacteria have *slime capsule* which provides greater pathogenicity and protects them against phagocytosis.

***Cell-wall*** is totally different from ordinary plant cell-wall. It is chemically complex and made up of amino acids, sugar and chitin but cellulose is totally missing. The cell-wall of most bacteria have unique macromolecule called *Peptidoglycan*. It is composed of long glycan chains cross-linked with peptide fragments. In addition sugar molecules, teichoic acid, lipoprotein and lipopolysaccharides are also present.

Some bacteria may lack cell-wall. Archaebacteria do not contain *Peptido-glycan*.

Cell-wall is found surrounding the cell-membrane. It is rigid, determines the shape and protects from osmotic lysis.

***Cell-membrane*** lies inside cell-wall. It is attached to cell-wall at few places and has many pores. It is made up of lipids and proteins. It acts as respiratory structure as *mitochondria* are absent.

***Cytoplasm*** is granular, having small vacuoles, glycogen-particles and ribosomes. Other membrane bounded cytoplasmic organelles are absent.

***Mesosomes*** are invagination of cell-membrane into the cytoplasm. Mesosomes are in the form of vesicles, tubules or lamellae. Their function is to help in DNA replication, cell-division, respiration and in export of enzyme.

***Nucleoid*** is prokaryotic nucleus caontaining genatic material DNA in the form of single circular molecule agregates as an irregular shaped dense structure called **chromatin body** or **bectrial-chromosome**. There is total absence of nuclear membrane, nucleoplasm and nucleolus.

***Plasmid*** is small fregment of extra genetic material double stranded DNA. It is self replicating and not associated with growth and metabolism. Plasmids serve as vectors in genetic engineering.

**Form (Shapes):**

There are four shapes of bacteria (Fig. 6.2).

**1. *Cocci*** (Singular–Coccus= Gr. Kokkos = Berry, rounded)

Cocci are spherical and non-flagellated. According to mode of division and cell arrangments there are several types of Cocci.

***Monococcus*** means one and ***Diplococcus*** means a pair of Cocci. ***Streptococcus*** is a long chain of Cocci. ***Tetrad*** having four Cocci. ***Sarcina*** is a cube of eight Cocci and ***Staphylococcus*** have grape like arrangements.

**2. *Bacilli*** (Singular–Bacillus = L. Bakulus = A rod).

Bacilli are rod-shaped. They may be found in pairs or in chains. e.g. Bacillus, Pseudomonas, Diplobacillus, Streptobacillus etc. They may be flagellated.

Bacilli are of following types:

***Bacillus*** is a single rod shaped bacterium. ***Streptobacillus*** is a chain of bacilli. ***Diplobacillus*** is a pair of bacilli.

**3. *Spirilla*** (Singular–Spirillum= Gr. SPEIRA= A coil)

They are spiral or cork-screw shaped e.g. ***Spirochaeta***.

**4. *Vibrio*** or ***Commas:***

They are slightly curved e.g.: Vibrio cholera. They may be flagellated.

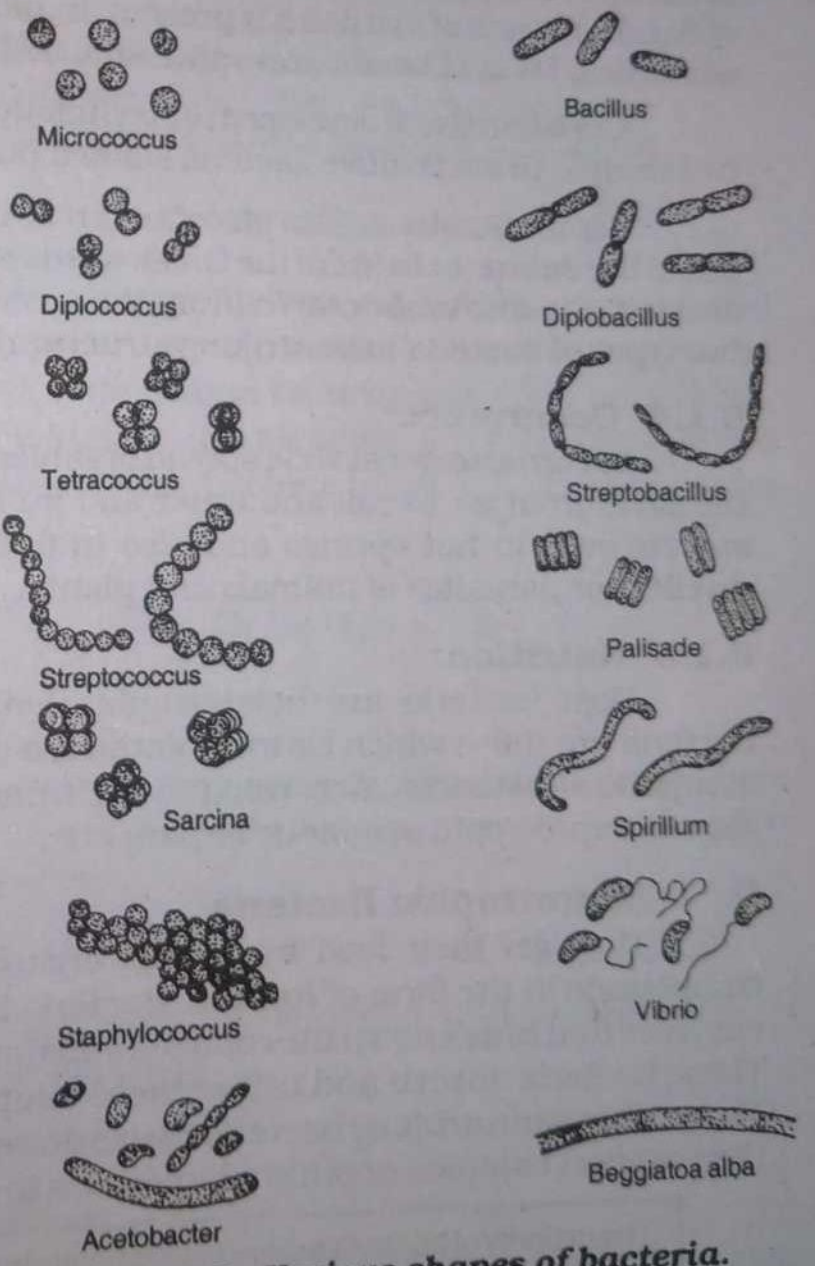



***Fig. 6.2 Various shapes of bacteria.***

### 6.1.3 Diversity:

Bacteria are difficult to classify. The classification of bacteria poses particular challenges to taxonomists. Because bacterial reproduction is usually asexual, bacterial species cannot be defined on the basis of their ability to interbreed. In addition, the fossil record of bacteria is quite sparse. Consequenty, taxonomists classify bacteria using a variety of criteria: shapes, means of locomotion, pigments, staining properties, nutrient requirements and the appearance of bacterial colonies.

On the basis of presence, pattern of attachment and the number of flagella present, **bacteria** are calssified into diffrent taxonomic groups. ***Atrichous*** means bactaria are without any flagella. When single polar flagellum is present then condition is known as ***monotrichous***. If a tuft of flagella is present only at ane pole of bactaria then these are ***lophotrichous***. ***Amphitrichous*** is a condition when tuft of flagella at each of two poles is present. In ***peritrichous*** form flagella surround the whole cell. Most of bacilli and spiral shaped bactaria have flagella.

Christian Gram developed the technique of gram staining, dividing bacteria into two groups. Gram positive bacteria stained purple and gram negative stained pink.

Some microbiologists place bacteria in two Major Categories: a large division called the ***eubacteria*** (from the Greek words for "true bacteria") and a much smaller division, the ***archaebacteria*** (from the greek words for "ancient bacteria"). These two types of bacteria have striking structural and biochemical differences.

### 6.1.4 Occurrence:

Bacteria are most wide spread organisms, which can be found distributed on the earth from air to soil and water and from dead to living organisms. They can survive even in hot springs and also in freezing temperature. They may be soil dwellers or parasites of animals and plants.

### 6.1.5 Nutrition:

Most bacteria are heterotrophic with a few autotrophic. Heterotrophic bacteria are those which cannot synthesize their organic compounds from simple inorganic substances. According to their mode of feeding, heterotrophic bacteria may be saprotroph, symbiotic or parasitic.

#### i) Saprotrophic Bacteria:

They get their food from dead organic matter. The soil is full of organic compounds in the form of ***humus***. Bacteria living in the soil have large number of enzymes that break down the complex substances of humus to simpler compounds. These bacteria absorb and utilize these simple compounds as a source of energy. Many other saprotrophic bacteria cause decay of dead animal and plant material as they convert complex organic compounds to simpler ones.

> The majority of bacteria are free-living heterotrophs (saprotrophic decomposers) that contribute significantly to recycling matter through ecosystems. Many are also symbiotic heterotrophs, including those that cause disease.

**ii) Symbiotic Bacteria:**

They are found associated with other living organisms. They obtain food from the host without harming it. e.g. *Rhizobium radicicola* occurring as symbionts in the nodulated roots of leguminous plants e.g. *Pisum sativum*.

**iii) Parasitic Bacteria:**

They grow inside the tissues of other living organisms and obtain food at the expense of host. These bacteria (*Pneumococcus*) lack certain complex systems of enzymes.

**iv) Autotrophic Bacteria:**

They can synthesize organic compounds from simple inorganic substances. Autotrophic bacteria may be photosynthetic or chemosynthetic.

> Autotrophic bacteria include those that are photosynthetic and those that are chemosynthetic. Among the photosynthetic bacteria, there are those that evolved first and do not give off oxygen and those (cyanobacteria) that evolved later and do give off oxygen.

**v) Photosynthetic Bacteria:**

Bacteria which synthesize organic compound by using light energy are called photosynthetic bacteria. They have pigments very similar to the chlorophyll and named as ***bacterio-chlorophyll*** or ***chlorobium-chlorophyll*** (Von Neil–1930). These pigments are present on invaginated plasma membrane in the cytoplasm and not in the chloroplasts. During photosynthesis, bacteria utilize $H_2S$ instead of water and liberate sulphur instead of oxygen.

$$CO_2 + 2H_2S \xrightarrow[\text{Chlorophyll}]{\text{Light}} (CH_2O)_n + H_2O + 2S$$

**vi) Chemosynthetic Bacteria:**

Bacteria which synthesize organic compound by obtaining energy from oxidation of some inorganic substances like iron, hydrogen, nitrogen and sulphur compounds are chemosynthetic bacteria.

### 6.1.6 Respiration:

Another aspect of metabolism which can be used in the classification of bacteria is their need for oxygen in respiration.

***Aerobes*** require oxygen for respiration.

***Anaerobic*** respire without oxygen.

***Facultative Bacteria*** respire with or without oxygen. Some bacteria require a low concentration of oxygen for growth and are known as ***micro-aerophilic***.

Some bacteria are killed in the presence of oxygen, they are called ***obligate anaerobes***. Others use oxygen but can respire without it, they are called ***facultative anaerobes***. Bacteria which can only survive in the presence of oxygen are ***obligate aerobes***.

### 6.1.7 Locomotion:

Some Bacteria can move using simple flagella that are attached with a unique wheel-like structure.

These are simpler in structure than the flagella seen in some eukaryotic cells. Bacterial flagella, which may either cover the cell or form a tuft at one end can rotate rapidly, propelling the bacterium through its liquid environment. Recent research has revealed a unique wheel-like structure embedded in the bacterial membrane and cell wall that allows the flagellum to rotate. Flagella allow bacteria to disperse into new habitats to migrate toward nutrients, and to leave unfavourable environments. Flagellated bacteria show orientation toward various stimuli, a behaviour called ***taxis***. Some are chemotactic, moving toward chemicals given off by food or away from toxic chemicals. Some are phototactic moving toward or away from light, depending on the habitat they require. Other flagellated bacteria are magnetotactic. These detect Earths magnetic field using magnets formed from iron crystals within their cytoplasm.

### 6.1.8 Growth:

Bacteria have a large surface area to volume ratio and can therefore gain food sufficiently rapidly from their environment by diffusion and active transport mechanisms.Therefore, provided conditions are suitable, they can grow very rapidly. Important environmental factors affecting growth are temperature, nutrient availability, pH and ionic concentrations. Oxygen must also be present for obligate aerobes and absent for obligate anaerobes. Four distinct phases are recognized in bacterial growth curve.

i) ***LAG Phase:*** Inactive phase or phase during which bacteria prepare themselves for division.

ii) ***LOG Phase:*** Bacteria grow and multiply very rapidly.

iii) ***Stationary Phase:*** Bacterial multiplication is equal to death rate.

iv) ***Death/Decline Phase:*** Death rate is more rapid than multiplication rate.

### 6.1.9 Reproduction:

Bacteria generally reproduce when conditions are favourable by asexual method called **fission**. However **endospore formation** takes place when conditions are not favourable.It is a method of survival under unfavourable conditions.

Bacteria lack traditional sexual reproduction and mitosis. However some

bacteria undergo genetic recombination by bacterial conjugation, transduction and transformation.

**Fission:**

Bacteria generally reproduce asexually by a process called ***binnary fission***.

Fission is the fastest mode of asexual reproduction found in the living organisms particularly unicellular.

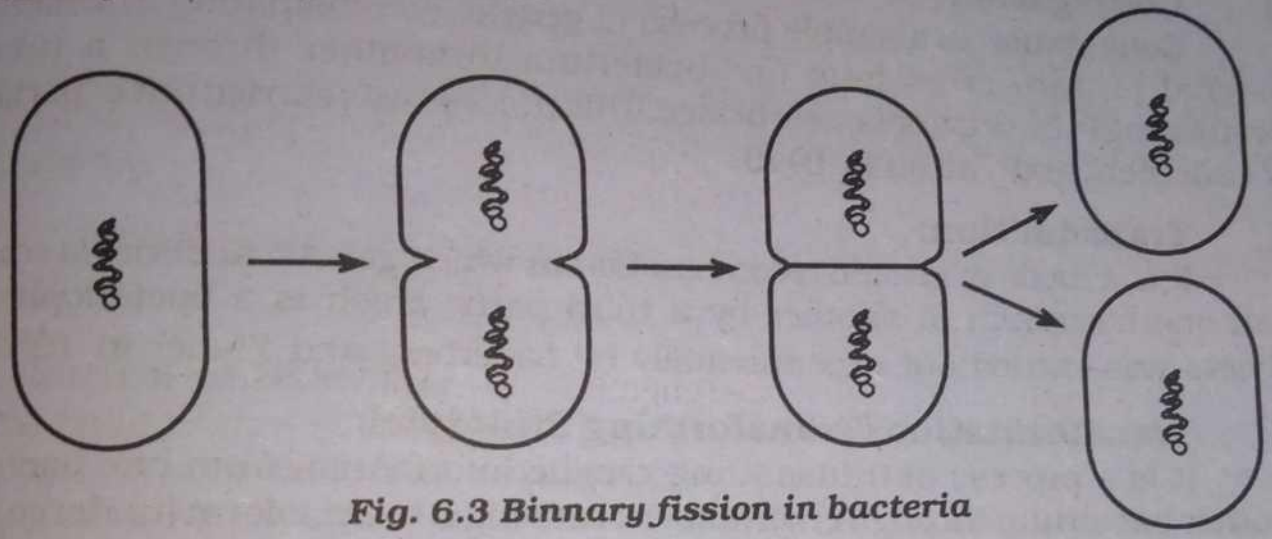


***Fig. 6.3 Binnary fission in bacteria***

Fission takes place when there is ample supply of food and moisture with favourable conditions. During fission, first the hereditary material (DNA) in the form of chromatin-body is replicated. Chromatin bodies so formed move apart. Then a constriction appears around the middle of the cell and it splits into two parts. These parts grow in size and form mature bacterial cells. The single fission takes about 20—30 minutes to complete.

Prokaryotes reproduce asexually by binary fission. Mutations are the chief means of achieving genetic variation.

**Endospore formation:**

During endospore formation, the whole protoplasmic content gets shrink into a small mass. A cyst is formed inside the parental wall around this mass to form

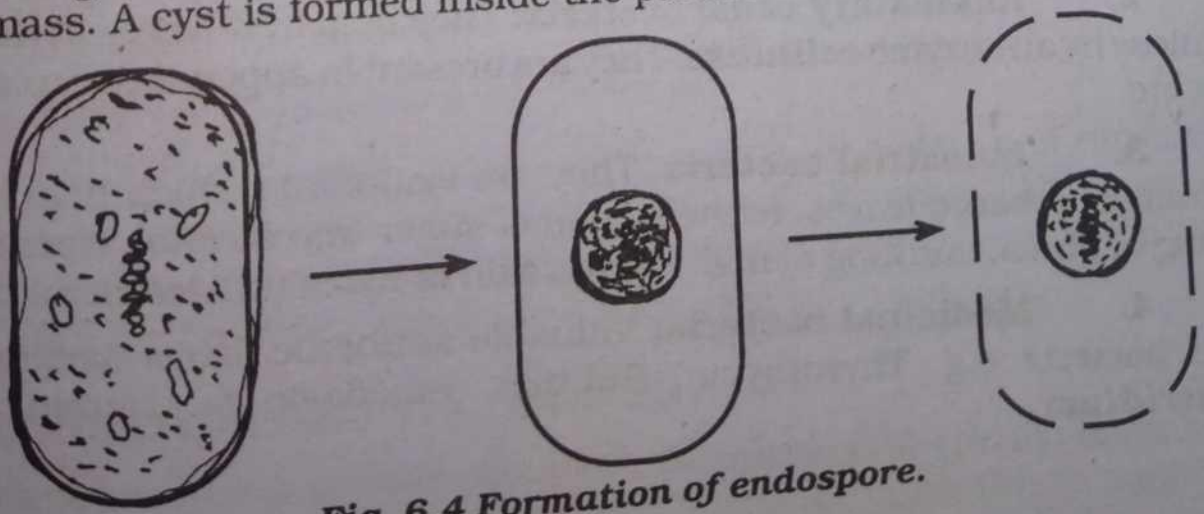


***Fig. 6.4 Formation of endospore.***

endospore. When parental wall ruptures due to decay, endospore is set-free. On the return of favourable conditions, this endospore enlarges to form mature bacterial cell.

**Genetic Recombination:**

The re-union of genetic material from two different sources is called genetic recombinations.Three methods by which genetic recombination takes place in bacteria are, conjugation, transduction and transformation.

**a) Conjugation:**

Conjugation is a simple process of genetic recombination in which genetic material is transferred from one bacterium to another through a tube called conjugating tube or cytoplasmic bridge. This process was carried out experimantally by Laderberg and Tatum in 1946.

**b) Transduction:**

It is a mode of genetic recombination in which genetic material is transferred from one bacterium to another by a third party which is a bacteriophage. This process was carried out experimentally by Laderberg and Zinder in 1952.

**c) Transformation (Transforming Principle):**

It is a process of transmitting genetic information from one bacterium to another bacterium through environment causing it to transform (undergo change). This principle was first notified by Fred Griffth in 1928.

## 6.2 IMPORTANCE AND CONTROL

### 6.2.1 Importance of Bacteria:

**Useful Bacteria:**

1. **Decomposers:** Bacteria are the important biotic component of each and every ecosystem . They act on dead plant and animal bodies decompose various organic compounds into simple forms such as nitrates, sulphates, phosphates etc. for utilization by green plants again. Nitrifying bacteria convert the proteins of these dead bodies into nitrates. Soil bacteria increase the fertility of the soil by bringing about physical and chemical changes in the soil.

2. **Alimentary canal bacteria:** They help herbivores in the digestion of cellulose by an enzyme ***cellulase***. They are present in appendix or in caecum of cow, goat etc.

3. **Industrial bacteria:** They are symbionts which help in curing and ripening of tobacco leaves, fermentation of sugar into alcohol, ripening of cheese, retting of fibres, curdling of milk, conversion of hides into leather etc.

4. **Medicinal bacteria:** Valuable antibiotic drugs have been obtained from bacteria e.g. Thyrothycin, Subtilin. Riboflavin is vitamin produced by ***clostridium***.

5. **Genetically engineered bacteria (Biotechnology):** E.coli has already been programmed to make human growth hormones for the treatment of growth deficiencies and insulin for diabetics.

**Harmful Bacteria:**

1. **Pathogenic bacteria:** They are responsible for many diseases in human beings, animals and plants. They may be called as invisible enemies of man.

Some of the diseases found in man due to bacteria are typhoid, tetanus, food–poisoning, diphtheria, tuberculosis etc. Plant diseases caused by bacteria are black-rot of cabbage, citrus canker, fire-blight of pear and apple, ring-rot of potato etc.

2. **Food spoilage:** Bacteria spoil food by fermentation, putrification or decomposition.

### 6.2.2 Control of Bacteria:

The term control of pathogenic organisms refers to bringing the infections in population to a tolerable limit. Control of bacteria is essential for the prevention diseases and to avoid spoilage of food and other industrial products. Several measures are taken to control infectious micro-organisms. Such measures involve the following:

i) Treatment of the infected individuals,

ii) Prophylactic treatment of the population at risk through immunization or vaccination,

iii) Disruption of the life cycle of the pathogen at all possible stages,

iv) In case of epidemics, prevention of the spread of infection to non-infected individuals through quarantine,

v) Identification and control or treatment of the reservoir hosts if any,

vi) Health awareness in masses primarily to reduce the risk factors related to some disease,

vii) Establishing a surveillance system.

viii) Killing of bacteria is brought about by a number of sterilization methods like exposing bacteria to ultraviolet rays or to high temperature. Certain antiseptics, antibodies and chemotherapy agents are used to kill the bacteria present in a living tissue.

## 6.3 IMMUNIZATION AND VACCINATION

Immunization refers to various processes of induction of specific immunity by injecting antigens, antibodies or immune cells. It can be protective or curative in

nature. It promotes increased immunity against specific diseases. Moreover, it not only provides long lasting protection against some diseases but also helps the infected individuals to fight with the pathogens.

There are many ways of immunization, one is called ***vaccination*** or active immunization. It is a prophylactic in nature and refers to the inoculation of host with inactive or weakened pathogens or pathogenic products to stimulate protective immunity. Thus in case of subsequent natural infection with the same pathogen, the immune system easily recognizes the invader and comfortably manages to over come the pathogen. In such cases, either no symptoms appear at all or mild symptoms appear. A vaccine is either taken orally (e.g. polio vaccine) or injected into the body (e.g. tetanus vaccine).

Immunization procedures are not only beneficial to the individuals but are effective public health procedures because disease spreads poorly through a population in which a large proportion of individuals are immune.

## 6.4 USE AND MISUSE OF ANTIBIOTICS

Antibiotics are chemical substance produced by certain micro-organisms that inhibit or kill some other micro-organisms. They have a dramatic impact on the treatment of infectious diseases. Since the discovery of the first antibiotic, penicillin which was derived from fungi in 1940, a large number of antibiotics have been discovered from other fungi and bacteria, while many are synthesized artificially.

Some antibiotic drugs are effective against only certain types of bacteria while others known as broad spectrum antibiotics are effective against wide range of bacteria. The targets of antibiotics in bacteria are cell-wall, plasma membrane and biosynthetic processes of proteins and nucleic acids.

Besides, medical usage, they are also used in agriculture both as growth promoting substances in animal feeds and as prophylactics (disease preventing).

However, either medically or agriculturally, their inappropriate and extensive use is leading to the rapid development of antibiotic resistance in pathogenic micro-organisms. Antibiotic resistance refers to the acquired ability of an organism to resist the effect of an antibiotic to which it is normally susceptible. Antibodies also have many side effects and their unnecessary and prolonged use distributes the metabolic activities of the user. The most common adverse reaction is many types of allergic reactions.

## 6.5 CYANOBACTERIA (Blue-green algae)

### 6.5.1 Salient features:

1. They are prokaryotes.
2. They are unicellular or may occur in colony form.

3. Cell-wall is double layered.
4. Protoplasm is differentiated into an outer coloured region ***chromoplasm*** and an inner colourless region ***centroplasm***.
5. Chromoplasm contains various pigments in which chlorophyll—***a*** and phycocyanin are in abundance imparting bluish green colour.
6. They are aquatic (fresh water, with a few marine forms).
7. Total absence of sexual reproduction.
8. Asexual reproduction takes place by means of hormogonia, zoospores, akinetes and fragmentation.

Nostoc may be taken as a typical example of Blue-green algae.

## 6.5.2 Nostoc:

### i) Structure:

Nostoc is unicellular, fresh water, prokaryots found in colony called filament. The filaments are intermixed in a gelatinous mass forming a ball like structure called ***coenobium***. It floats on water. A single filament (Trichome) look like a chain of beads. Each filament is unbranched and has a single row of rounded or oval cells. Each cell has double layered wall. The outer thicker layer is made up of cellulose mixed up with pectic compound. The inner thin layer is purely made up of cellulose. The protoplasm is differentiated into an outer coloured region, chromoplasm and an inner colourless region centroplasm. The chromoplasm is coloured due to the presence of various pigments like chlorophyll – ***a***, xanthophyll, carotene, phycocyanin and phycoerythrin. These pigments are not located in plastids but in side an invaginated plasma membrane (a primitive character).

There is total absence of endoplasmic reticulum, mitochondria, Golgi bodies and vacuole. However ribosomes, pseudovacuoles and reserve food in the form of cyanophyceae starch are present.

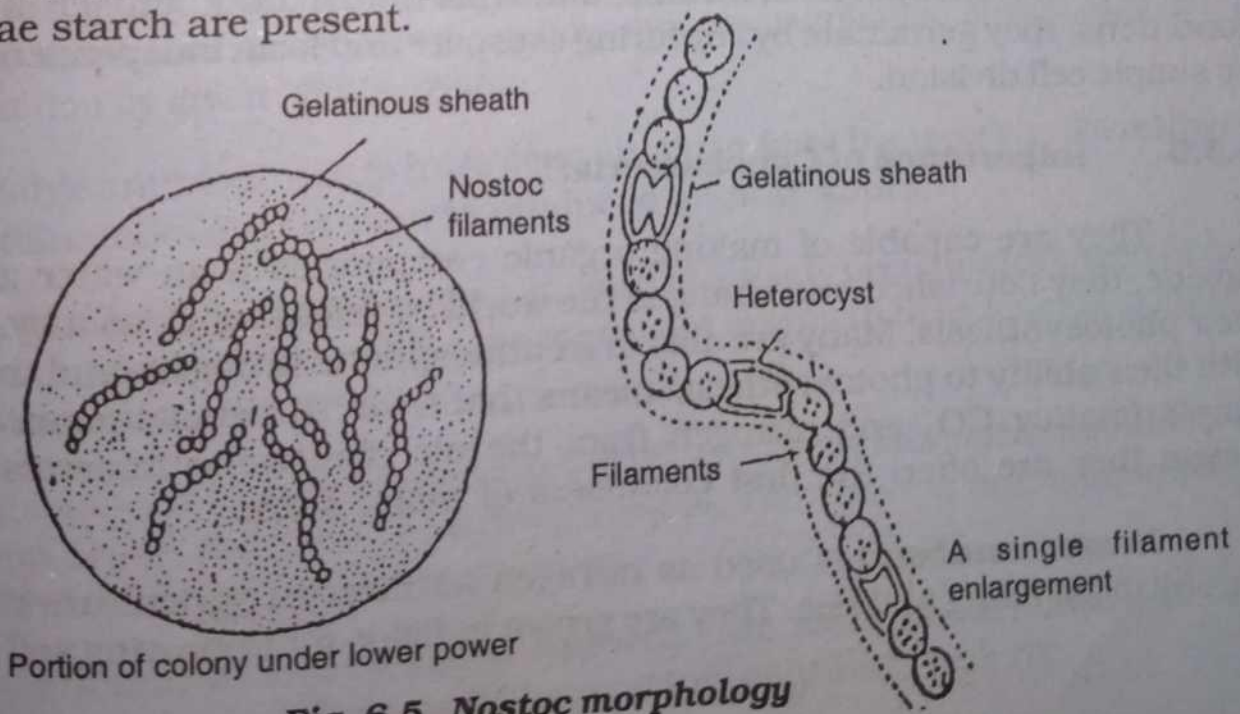



***Fig. 6.5 Nostoc morphology***

The centroplasm, also called central-body has hereditary material in diffused form, because there is no nuclear membrane, nucleolus and typical chromosomes.

At intervals there are found slightly larger oblong, colourless cells with slightly thicker walls. These are called ***heterocyst***. Each heterocyst is the centre of nitrogen fixation. But they are specially concerned in the multiplication of filaments during unfavourable conditions.

**ii) Nutrition:**

Nostoc is an autotroph like all other blue-green-Algae. It is also capable of fixing atmospheric nitrogen and converts it into nitrates to make amino-acids and proteins. This activity takes place in heterocyst.

**iii) Reproduction:**

There is no report of sexual-reproduction in nostoc. But asexual reproduction takes place by following methods.

**a) Hormogonia (Sing = Hormogonium):** Hormogonium is a portion of filament between two heterocysts. During favourable conditions, filament breaks up at the junction of each heterocyst. This results in the formation of a number of pieces called *hormogonia*. The end cells of each hormogonium divide to form long filament of nostoc.

**b. Akinetes:** Akinetes are non-motile spores formed from certain vegetative cells during unfavourable conditions.

When conditions are not favourable, certain vegetative cells become enlarge and thick–walled containing reserve food, called akinetes. These are somewhat oval with outer layer ***exosporium*** and inner ***endosporium***. At the approach of favourable conditions, they germinate by rupturing exospore and form independent filaments by simple cell division.

### 6.5.3 Importance of Cynobacteria:

They are capable of making organic compounds from water and carbon dioxide, they flourished and changed the world by releasing $O_2$ as a by-product of their photosynthesis. Many are able to fix atmospheric nitrogen, and this together with their ability to photosynthesis means that their nutritional requirements are simple (mainly $CO_2$ and nitrogen from the air plus some minerals). For this reason they are often the first colonisers of moist soils.

***Nostoc anabena*** is used as nitrogen fertilizer in agriculture due to their high nitrogen fixing abilities. They are grown in fields for improving soil fertility.

# KEY POINTS

- Prokaryotes are unicellular organisms in which each cell contains a single DNA molecule coiled in a loop and not enclosed in a nuclear membrane.
- Antony Van Leeuwenhoek, was the first to observe micro organisms. He constructed a simple microscope and observed a drop of water.
- Bacteria are the pioneers of cellular organization and strictly ***unicellular***. However the cells of some species may remain associated after cell-division and form colonies.
- Mesosomes are invagination of cell-membrane into the cytoplasm. Mesosomes are in the form of vesicles, tubules or lamellae. Their function is to help in DNA replication, cell-division, respiration and in export of enzyme.
- Bacteria are difficult to classify. Taxonomists classify bacteria using a variety of criteria: shapes, means of locomotion, pigments, staining properties, nutrient requirements and the appearance of bacterial colonies.
- Some bacteria are killed in the presence of oxygen, they are called obligate anaerobes. Others use oxygen but can respire without it, they are called facultative aerobes. Bacteria which can only survive with oxygen present are obligate aerobes.
- Some Bacteria can move using simple flagella that are attached with a unique wheel-like structure.
- Bacteria act on dead plant and animal bodies and decompose various organic compounds into simple forms such as nitrates, sulphates, phosphates etc. for utilization by green plants again.
- Valuable antibiotic drugs have been obtained from bacteria e.g. Thyrothycin, Subtilin. Riboflavin is vitamin produced by clostridium.
- Genetically engineered bacteria, E.coli has already been programmed to make human growth hormones for the treatment of growth defeciencies in children and the insulin for dibetics.
- Antibiotics are chemical substance produced by certain microorganisms that inhibit or kill some other microorganisms. They have a dramatic impact on the treatment of infectious diseases.
- Nostoc found in colony called filament. The filaments are intermixed in a gelatinous mass forming a ball like structure called coenobium.

# EXERCISE

**1. Encircle the correct choice:**

(i) Extremely thin appendages helping during conjugation in bacteria:

(a) Flagella (b) Pili

(c) Celia (d) Tentacles

(ii) Spirochaeta is an example of:

(a) Cocci (b) Bacilli

(c) Spirilla (d) Vibrio

(iii) Inactive phase or phase of growth during which bacteria prepare themselves for division:

(a) Lag-phase (b) Log-phase

(c) Stationary phase (d) Decline phase

(iv) Bacteria having flagella all over the surface:

(a) Atrichous (b) Lophotrichous

(c) Peritrichous (d) None of them

(v) Non-motile spores formed from certain vegetative cells during unfavourable conditions in nostoc:

(a) Heterocyst (b) Hormogonium

(c) Akinete (d) Coenobium

(vi) Photosynthetic bacteria liberate:

(a) $CO_2$ (b) $O_2$

(c) S (d) $H_2S$

(vii) Type of cocci having group eight:

(a) Streptococcus (b) Sarcinia

(c) Staphyloccous (d) Diplococcous

2. **Write detailed answers of the following questions:**

(i) Describe structure and modes of reproduction in bacteria.

(ii) Descibe salient features of cynobacteria and reproduction in nostoc.

(iii) Distinguish between bacterial and nostoc cell. Give positive importance of bacteria and nostoc.

3. **Write short answers of the following questions:**

(i) How bacteria were discovered?

(ii) What are Photosynthetic bacteria?

(iii) How bacteria are classified on the bases of flagella?

(iv) What are cyanobacteria?

(v) Does genetic recombination takes place in bacteria? Define any one method.

4. **Define the following terms:**

(i) Hormogonia (ii) Heterocyst (iii) Prokaryotae

(iv) Mesosomes (v) Plasmid (vi) Nucleoid (bacteria)

5. **Distinguish between the following:**

(i) Flagella and pili

(ii) Photosynthetic and chemosynthetic bacteria