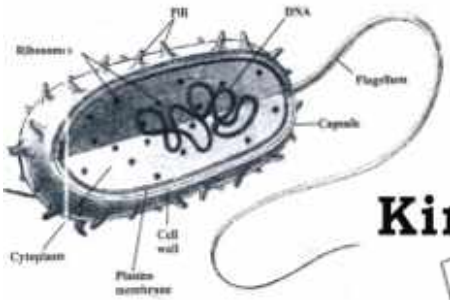


Chapter 6

Kingdom Prokaryotae (Monera)

6.1 INTRODUCTION

Kingdom Prokaryotae consists of organisms with prokaryotic cells. In Greek the word 'pro' means "before" and "karyon" means "nucleus".

- Microbiologists place bacteria in two major categories:

(i) ***Eubacteria*** (Greek for "true bacteria").

(ii) ***Archaeobacteria*** (Greek for" ancient bacteria"), that is a much smaller division.

6.2 DISCOVERY OF BACTERIA

It had long been suspected that small creatures exist which are too small to be seen with naked eye. But their discovery was linked to the invention of microscope.

(i) Work of Antonie Van Leeuwenhoek

A Dutch Scientist "Antonie Van Leeuwenhoek" (1673) was the first to report the microbes such as bacteria and protozoa.

He used a simple microscope to describe bacteria and protozoa with accurate drawings and descriptions and called these small creatures as ***"animalcules"***.

- Firstly he observed small creatures in rain water.
- Then he confirmed these in saliva, vinegar, infusions and other substances.

(ii) Work of Louis Pasteur

The progress in understanding the nature and importance of these tiny organisms has been slow. The existence of microbes was further confirmed by Louis Pasteur's work. Pasteur went on making many discoveries in the field of microbiology and medicine.

Achievements

His main achievements are;

- The development of ***vaccines*** for disease ***anthrax, fowl cholera*** and ***rabies***.
- He also made significant contributions in development of ***pasteurization*** process and development of fermentation industries.
- He proved that microorganisms could cause disease.

(iii) Work of Robert Koch

Achievements

i) Robert Koch formulated the ***'germ theory of disease'*** he isolated typical rod-shaped bacteria with squarish ends (bacilli) form the blood of sheep that had died of anthrax.

ii) Then he discovered bacteria that caused ***tuberculosis*** and ***cholera***.

iii) Koch and his colleagues invented many techniques concerning inoculation, isolation, and media preparation, maintenance of pure cultures and preparation of specimens for microscopic examinations.

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Postulates of the Germ Theory of Disease

He formulated ***four postulates,*** which are the main pillars of the germ theory of disease.

1. A specific organism can always be found in association with a given disease.
2. The organism can be isolated and grown in pure culture in the laboratory.
3. The pure culture will produce the disease when inoculated into susceptible animal.
4. It is possible to recover the organism is pure culture from experimentally infected animal.

➢ These are used to find out whether the organism found in disease lesions is the causal agent of the disease or not

QUESTION RELATED TO ABOVE ARTICLE

Write notes on. **(Exercise Question v)**

Koch's postulates

6.3 OCCURRENCE OF BACTERIA

Bacteria are wide spread in their occurrence. Their kind and number vary according to locality and environmental conditions.

➢ They are found almost everywhere, in / on;

- Air
- Land
- Oil deposits
- Food
- Plants
- Animals
- Organic matter
- Man

➢ Some bacteria are always present and contribute towards the natural flora. Others are present in specific environments such as;

- Hot springs
- Alkaline/acidic soil
- Saline environment
- Polluted soils and waters

6.4 STRUCTURE OF BACTERIA

All Bacterial cells invariably have;

- Cell membrane
- Cytoplasm
- Ribosome
- Chromatin bodies etc

The majority have;

- Cell wall, which gives shape to the bacterial cell.

Specific structures which are not found in all bacteria are;

- Capsule
- Slime
- Flagella
- Pili
- Fimbriae
- Granules

6.4.1 SIZE

- Bacteria range in size from about 0.1 to 600 µm over a single dimension. Bacteria vary in size a much as in shape
- *Escherichia coli,* a bacillus of about overage size, is ***1.1 to 1.5 um in length.***
- *Staphylococci* and *Streptococci* are ***0.75-1.25um in diameter.***
- The ***smallest*** (e.g., some members of the genus *Mycoplasma*) are about ***100 to 200 nm*** in diameter approximately the size of the largest viruses (poxviruses).

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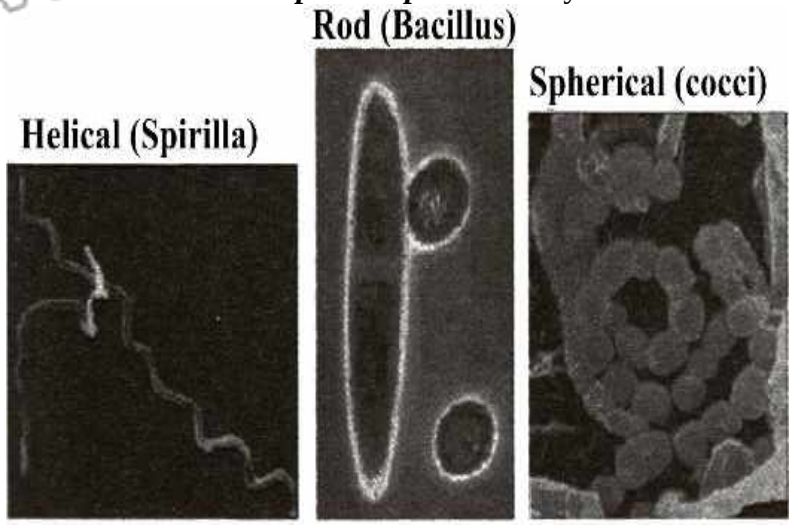
Recently a ***huge bacterium*** has been discovered in the intestine of the brown surgeonfish, ***Acanthurus nigrofuscus. Epulopiscium fishelsoni*** grows as large as 600 μm by 80 μm, a little smaller than a printed hyphen.
It is now clear that a few bacteria are much larger than the average eukaryotic cell.

6.4.2 SHAPE OF BACTERIA

On the basis of general shape, bacteria are classified into three categories. These shapes are known as

- Cocci
- Bacilli
- Spiral

➢ Although most of the bacteria species have fairly constant characteristic cell shape.
➢ Some cells are ***pleomorphic*** and they can exist in a variety of shapes.



Exceptions to the above shapes are:
- Trichome
- Sheathed Stalked
- Square
- Star-shaped
- Spindle-Shaped
- Lobed
- Filamentous bacteria

Fig. 6.1 Shapes of Bacteria

i. COCCI

The cocci are spherical or oval bacteria having one of several distinct arrangements based on their planes of division.

Diplococcus & Streptococcus

If ***division is in one plane*** it will produce either a diplococcus or streptococcus arrangement.

- When cocci occur in pairs then arrangement is ***diplococcus***,
- Whereas when cocci form long chain of cells then arrangement is called ***streptococci.***

Examples

Diplococcus pneumoniae and ***Staphylococcus aureus*** are some examples of cocci.

Tetrad

- When the ***division of cell is in two planes*** it will produce a tetrad arrangement.
- A tetrad is a square of 4 cocci.

Sarcina

- Thirdly, when the ***division is in three planes,*** it will produce a sarcina arrangement.
- A sarcina is a cube of 8 cocci.

Staphylococcus

- When ***division occurs in random planes,*** it will produce a staphylococcus arrangement, in which cocci are arranged in irregular, often grape-like clusters.

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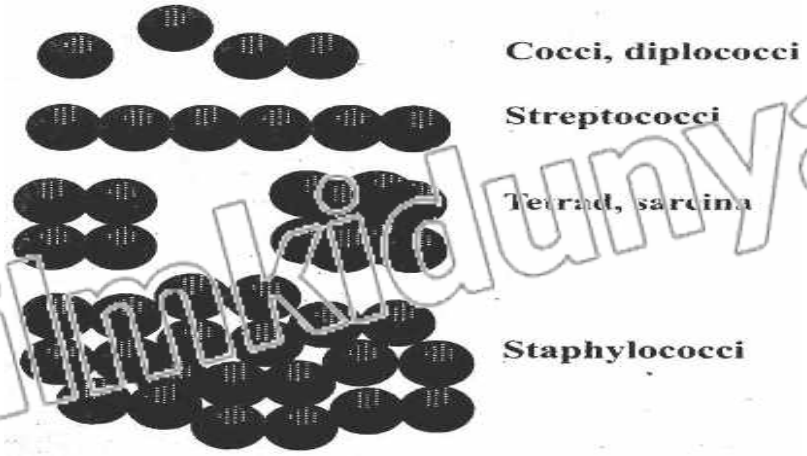


Fig. 6.2 Cocci

BACILLI

Bacilli are rod-shaped bacteria.

- Bacilli all **divide in one plane** producing a bacillus, streptobacillus, or diplobacillus.
- Bacillus is a single cell of bacteria.

Streptobacilli

- Streptobacilli is a chain of bacilli.

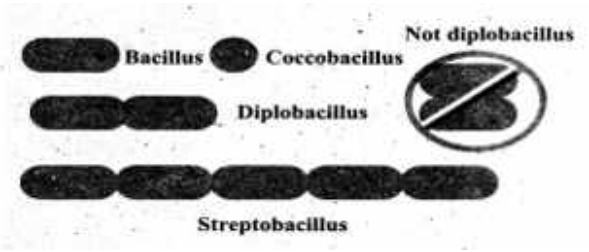


Fig 6.3 Bacilli

Diplobacilli

- When rod shaped bacteria occur in pairs then
- arrangement of cells is known as diplobacilli.

Examples of rod shaped bacteria are:

Escherichia coli, Bacillus subtilis, Pseudomonas.

iii. SPIRAL

The spiral shaped bacteria are spirally coiled. Spirals come in one of three forms.

- A ***vibrio*** is curved or comma-shaped rod.
- ***Spirillum*** is a thick, rigid spiral.
- ***Spirochete*** is a thin, flexible spiral.

Examples of spiral shaped bacteria are *Vibrio, Hyphomicrobium.*



Fig **6.4** Spirilla

QUESTION RELATED TO ABOVE ARTICLE

Write notes on. (Exercise Question v)

Shapes of bacteria

6.4.3 BACTERIAL CELL STRUCTURE

Flagella and their Factions

These are extremely thin, hair like appendages. They come out through cell wall and originate from ***basal body***, structure just beneath the cell membrane in the cytoplasm. They are made up of protein ***flagellin***.

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Classification of Bacteria on the Bases of Flagella

On the basis of presence of flagella, pattern of attachment of flagella and the number of flagella present bacteria are classified into different taxonomic groups.

- ***Atrichous*** means bacteria are without any flagella.
- When single polar flagellum is present then condition is known as ***monotrichous***.
- If tuft of flagella is present only at one pole of bacteria then these are ***lophotrichous*** flagella.
- ***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 bacteria have flagella.
- Cocci very rarely have flagella.

Function of Flagella

Primary function of flagella is to help in motility.

- With the help of flagella, flagellated bacteria can also detect and move in response to chemical signals which is a type of behaviour called as ***Chemotaxis.***

6.4.4 PILI AND THEIR FUNCTIONS

These are hollow, filamentous appendages.

- Pili are ***smaller than flagella*** and are ***not involved in motility***.
- True pili are ***only present on gram-negative bacteria.***
- They are made up of special protein called ***pilin***.
- They are primarily involved in a mating process between cells called ***conjugation*** process.
- Some pili function as a means of attachment of bacteria to various surfaces.

QUESTION RELATED TO ABOVE ARTICLE

Write notes on. **(Exercise Question v)**

a) Flagella and Pili

6.4.5 THE CELL ENVELOPE: THE OUTER WRAPPING OF BACTERIA

Bacterial surface and walls are diverse.

- Collectively ***complexes of layer external to the cell protoplasm*** are called as cell envelope and include capsule, slime and cell wall.

Capsule

- Bacteria produce capsule, which is made up of repeating polysaccharide units, and of protein, or of both.
- Capsule is ***tightly bound*** to the cell.
- It has a thicker, ***gummy nature*** that gives sticky characters to colonies of encapsulated bacteria.

Slime

- Some bacteria are covered with ***loose, soluble shield*** of macromolecules which is called as slime capsule.
- Slime provides ***greater pathogenicity*** to bacteria and protects them against ***phagocytosis***.

Cell Wall

- Beneath the extra cellular substances and external to cytoplasmic membrane cell wall is present.
- It is a ***rigid*** structure.
- It determines the shape of bacterium.
- Cell walls also **protect** the cells from osmotic lysis.
- Cell wall is only absent in ***mycoplasmas***.

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Work of Christen Gram

Christian Gram developed the technique of Gram staining.

Bacteria could be divided into two groups based on their response to gram staining procedure.

- By this staining technique ***Gram-positive bacteria*** are ***stained purple*** (retain the primary dye due to formation of CV-I complex).
- ***Gram negative bacteria*** are ***stained pink*** (retain secondary dye) in colour.

  There are many structural differences between two groups, which are the primary basis for difference in staining behaviour.

Characteristics	Gram-Positive	Gram-negative
Number of major layers Chemical make up	**1**	**2**
Chemical make up	Peptidoglycan (50% of dry weight in some bacterial cells) Techoic acid Lipotechoic acid Lipids (1-4%)	Lipopolysaccharides Lipoproteins Peptidoglycan 10% dry weight of some Bacterial cells Lipids (11-12%)
Overall thickness	20-80nm	8-11nm
Outer membrane	No	YES
Periplasmic space	Present in some	Present in all
Permeability	More permeable	Less permeable

Features of Cell Wall

- The cell walls of most bacteria have a unique macromolecule called as ***Peptidoglycan***.
- Its amount varies in different types of bacteria.
- It is composed of framework of long glycan chains cross-linked with peptide fragments.
- The intact cell wall also contains chemical constituents such as sugar molecules, teichoic acid, lipoproteins and lipopolysaccharides, which are linked to Peptidoglycan.

  Several bacteria groups lack the cell wall structure characteristic of gram positive or Gram negative bacteria and some bacteria have no cell wall at all.

➢ Cell walls of archaeobacteria are different from eubacteria. They do not contain Peptidoglycan. Their cell walls are composed of proteins, glycoproteins and polysaccharides.

6.4.6 CELL MEMBRANE

- Just beneath the cell wall is the cell membrane or plasma membrane.
- It is very ***thin, flexible*** and completely surrounds the cytoplasm.
- Plasma membrane is very delicate in nature, any damage to it results in death of the organism.
- Bacterial membranes differ from eukaryotic membranes in ***lacking sterols*** such as cholesterol.

Functions of Bacterial Membrane

- Cell membrane regulates the transport of proteins, nutrients, sugar and other metabolites.
- The plasma membranes of bacteria also contain enzymes for respiratory metabolism.

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6.4.7 CYTOPLASMIC MATRIX

The cytoplasmic matrix is the substance present between the plasma membrane and the nucleoid.

- The cytoplasm of prokaryotic cell ***lacks membrane bound organelles and cytoskeleton*** (microtubules).
- It has ***gel like consistency.*** Small molecules can move through it rapidly.
- The plasma membrane and everything present within it, is known as ***protoplast***. Thus the cytoplasmic matrix is the major part of protoplast.
- Other large discrete structures such as chromatin/nuclear body, mesosomes and granules and nucleoid are present in this matrix.

6.4.8 NUCLEOID

Bacterial cell unlike the cells of eukaryotic organisms lacks discrete chromosomes and nuclear membrane.

- The nuclear material or DNA in bacterial cells occupies a position near to the center of cell.
- This material is a ***single, circular*** and ***double stranded DNA molecule.***
- It aggregates as an irregular shaped dense area called the ***Nucleoid.***
- This ***chromatin body*** is actually an extremely long molecule of DNA that is tightly folded so as to fit inside the cell component.
- Since bacteria have a single chromosome, they are ***haploid.***

- Other names for nucleoid are nuclear body, chromatin body and nuclear region.
- It is visible in the light microscope after staining with ***Feulgen*** *stain*.
- ***Escherichia coli*** closed circle chromosome measure approximately 1, 4000 um.

6.4.9 PLASMID

- Many bacteria contain plasmids in addition to chromosomes.
- These are the ***circular, double stranded DNA molecules.***
- They are ***self-replicating*** and are not essential for bacterial growth and metabolism.
- They often contain ***drug resistant, heavy metals, disease*** and ***insect resistant genes*** on them.

Plasmids are important ***vectors,*** in modern genetic engineering techniques.

6.4.10 RIBOSOMES

- Ribosomes are composed of RNA and proteins.
- Some are freely dispersed and some may also be loosely ***attached to plasma membranes***
- They are protein factories.
- There are thousands of ribosomes in each healthy growing cell.
- They are ***smaller than eukaryotic ribosomes (70S).***

6.4.11 MESOSOMES

- The cell membrane invaginates into the cytoplasm forming structure called mesosome.
- Mesosomes are in from of ***vesicles, tubules or lamellae.***
- Mesosomes involved in ***DNA replication*** and ***cell division.***
- Whereas some mesosomes are also involved in ***export of exocellular enzyme.***
- ***Respiratory enzymes*** are also present on the mesosomes.

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6.4.12 GRANULES AND STORAGE BODIES

- Since bacteria exist in a very competitive environment where nutrients are usually in short supply.
- They tend to ***store extra nutrients*** when possible. These may be ***glycogen, sulphur, fat*** and ***phosphate.***
- In addition, cells contain ***waste materials*** that are subsequently excreted**.** For example, common waste materials are ***alcohol, lactic acid*** and ***acetic acid***.

6.4.13 SPORES

- Certain species of bacteria produce spores, either external the vegetative cells ***(exospores)*** or within the vegetative cells ***(endospores).***
- They are metabolically dormant bodies and are produced at a late stage of cell growth.
- Spores are ***resistant*** to adverse physical environmental conditions such as light, high temperature, desiccation, pH and chemical agents.
- Under favorable conditions they germinate and form vegetative cells.

6.4.14 CYSTS

- Cysts are ***dormant, thick-walled, desiccation resistant*** forms and develop during differentiation of vegetative cells which can germinate under suitable condition.
- They ***are not heat resistant***.

QUESTION RELATED TO ABOVE ARTICLE

Explain the structure of bacteria in detail.
Different between Gram positive and Gram-negative bacteria.
Write down the different taxonomic groups of bacteria on the basis of pattern of flagella. (GRW 2018)
Describe different shapes of bacteria. (FSD 2019)
Describe flagella and their functions. (GRW 2021)
Describe in detail the structure of bacterial cell wall, emphasizing on Gram positive and Gram negative properties. (Exercise Question i)

6.5 NUTRITION OF BACTERIA

Like other organism's bacteria need energy for their growth, maintenance and reproduction.

A) Heterotrophic Bacteria

Most bacteria are ***heterotrophic*** i.e, they cannot syntheses their organic compounds form simple inorganic substances.
They live either as saprophytes or as parasites.

i) Saprophytic Bacteria

Saprophytic bacteria get their food from dead organic matter.

- Soil is full of organic compounds in the form of humus. Humus is the material resulting from the partial decay of plants and animals.
- Many soil inhabiting bacteria have very extensive enzyme system that breaks down the complex substances of humus to simple compounds.
- The bacteria can then absorb and utilize these simpler substances as a source of energy.

ii) Parasitic Bacteria

Parasitic bacteria for their nutrition are fully dependent on their host.

B) Autotrophic Bacteria

Some kinds of bacteria are ***autotrophic*** i.e, they can synthesize organic compounds which are necessary for their survival from inorganic substances.

i) Photosynthetic Bacteria

Photosynthetic bacteria possess chlorophyll which differs from the chlorophyll of green plants. Unlike most green plants, which have their chlorophyll in chloroplasts, bacterial chlorophyll is dispersed in the cytoplasm. During photosynthesis the autotrophic bacteria utilize hydrogen sulphide ***(H_2S)*** instead of water as a hydrogen source and liberate sulphur instead of oxygen. Nitrifying bacteria are chemosynthetic.

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

Green sulphur bacteria, purple sulphur bacteria and purple non-sulphur bacteria are photosynthetic bacteria.

ii) Chemosynthetic Bacteria

Chemosynthetic bacteria oxidize inorganic compounds like ammonia, nitrate, nitrite, sulphur or ferrous iron and trap the energy thus released for their synthetic reactions. The overall reaction of photosynthesis in photosynthetic bacteria can be written as:

QUESTION RELATED TO ABOVE ARTICLE

Classify the bacteria according to their mode of nutrition.

Discuss the mode of nutrition in bacteria.

Discus nutrition in bacteria.

(LHR 2017, 2018, 2019, 2021, SWL 2021, BWP 2021, MTN 2021)

How bacteria are classified on the basis of nutrients and energy trapping methods?

(LHR 2022)

For growth, maintenance and reproduction nutrients are necessary. How bacteria get them? (RWP 2018, GRW 2022)

6.6 RESPIRATION IN BACTERIA

Respiration in bacteria may be aerobic (requiring free oxygen) or anaerobic not requiring free oxygen. Various mode of respiration is used by bacteria are;

- Bacteria, which are able to grow in the presence of oxygen, are called ***aerobic bacteria***. e.g; ***Pseudosomonas*** is an aerobic bacterium.
- While those which can grow in the absence of oxygen are known as ***anaerobic bacteria***. e.g; ***Spirochete*** is an anaerobic bacterium.
- Some bacteria are neither aerobic nor anaerobic but facultative. ***Facultative bacteria*** grow either in the presence or absence of oxygen. e.g; ***E. coli*** is a facultative anaerobic bacterium.
- Some bacteria require a low concentration of oxygen for growth and are known as ***microaerophilic***. e.g; ***Campylobacter*** is a microaerophilic bacterium.

QUESTION RELATED TO ABOVE ARTICLE

Explain the Respiration in bacteria.

Classify the bacteria according to respiration.

6.7 GROWTH AND REPRODUCTION

Bacterial growth refers commonly to increase in number of bacterial cells. Bacteria increase in number by an asexual means of reproduction, called ***binary fission***.

Procedure

- In binary fission parent cell enlarges, its chromosome duplicates, and plasma membrane pinches inward at the center of the cell. When nuclear material has been evenly distributed, the cell wall grows inward to separate cell into two.
- This sequence is repeated at intervals by each new daughter cell which in turn increases the population of cells.
- Once the division is complete, bacteria grow and develop their unique features.
- The interval of time until the completion of next division is known as ***generation time.***
- Four distinct phases are recognized in bacterial growth curve.

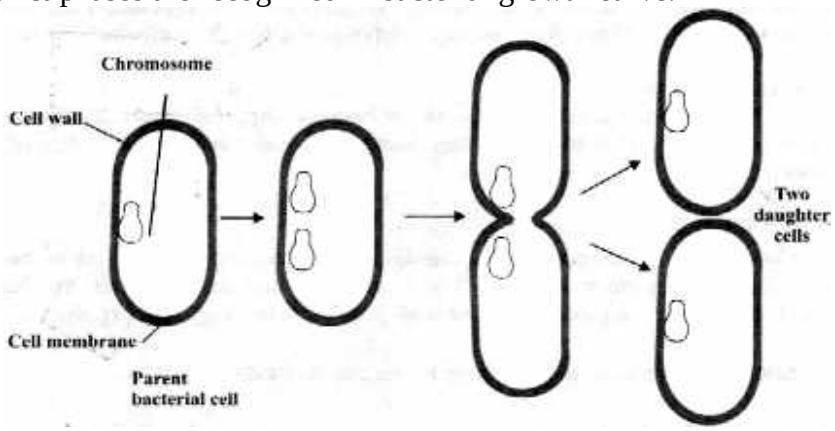


Fig. 6.6 Binary Fission in Bacteria

1) **Lag phase:** It is phase of no growth. Bacteria prepare themselves for division.
2) **Log phase:** It is phase of rapid growth. Bacteria divide at exponential rate.
3) **Stationary phase:** Bacterial death rate is equal to bacterial rate of reproduction and multiplication.
4) **Death/Decline phase:** Bacteria start dying. Here the death rate is more than reproduction rate.

Conjugation

Bacteria lack traditional sexual reproduction and mitosis. However, some bacteria transfer genetic material from a donor bacterium to a recipient during a process called ***conjugation***.

- Some conjugating bacteria use specialized sex pili to transfer genetic material.
- Conjugation produces new genetic combinations that may allow the resulting bacteria to survive under great variety of conditions.

QUESTION RELATED TO ABOVE ARTICLE

What is generation time? Describes the growth in bacteria.
Explain the reproduction in bacteria.
Describe growth and reproduction in bacteria. **(SGD 2019, FSD 2021)**
How bacteria increase their numbers? Write in detail. **(BWP 2022)**
Write notes on. **(Exercise Question v)**
a) Growth in bacteria

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6.8 IMPORTANCE OF BACTERIA

6.8.1 ECOLOGICAL IMPORTANCE

Bacteria are ecologically very important. They are highly adaptable as a group and are found nearly everywhere. They are able to decompose organic matter and play a significant role in the completion of cycles of nitrogen, phosphorus, sulfur and carbon.

6.8.2 ECONOMIC IMPORTANCE

- Bacteria are used in number of industries, including food, drugs (production of antibiotics) and in biotechnology.
- Bacteria are also responsible for spoilage of food and vegetables.
- Many plant pathogens adversely affect the agricultural industry.

6.8.3 MEDICAL IMPORTANCE

Bacteria are very common pathogens of humans. ***Approximately 200 species*** are known to cause diseases in humans. Many bacteria normally inhabit the bodies of man and other animals.

6.9 CONTROL OF BACTERIA

Control of microorganism is essential in home, industry as well as in medical fields.

Significance of Bacterial Control

- By controlling microorganisms, one can prevent and treat diseases.
- Spoilage of foods and other industrial products can be inhibited by controlling microorganisms.

Microorganisms can be controlled by various methods;

i) Physical Control

ii) Chemical Control

iii) Immunization/Vaccination

6.9.1 PHYSICAL METHODS

In this, steam, dry heat, gas, filtration and radiation are used to control bacteria.

Sterilization

The process in which we use physical agents to control bacteria/microorganism is known as sterilization process.

Sterilization is ***destruction of all life form***.

- ➢ High temperature is usually used in microbiological labs for control of microbes. Both ***dry heat*** and ***moist heat*** are effective.

i) Dry heat causes ***oxidation of chemical constituents*** of microbes and kills them.

ii) Moist heat causes ***coagulation of proteins*** and kills the microbes.

- ➢ Certain ***electromagnetic radiations*** below ***300 nm*** are effective in killing of microorganisms. ***Gamma rays*** are in general used for sterilization process.
- ➢ Heat sensitive compounds like antibiotics, sera's, hormones etc. can be sterilized by means of ***membrane filters***.

6.9.2 CHEMICAL METHODS

Modes of action of different chemical and physical agents of control vary. Damage can result malfunctions in cell wall, cell membranes, cytoplasm enzymes, or nucleic acid.
For microbial control one can use:

i) Antiseptics
ii) Disinfectants
iii) Chemotherapeutic agents

(i) Antiseptics

Chemical substances used on living tissues that inhibit the growth of microorganism are called antiseptics**,** e.g; Dettol etc.

(ii) Disinfectants

The important chemical agents used for disinfection are oxidizing and reducing agents. e.g; halogens, hydrogen peroxide, potassium permanganate, alcohol and formaldehyde etc.
They inhibit the growth of vegetative cells and are used on nonliving materials.

(iii) Chemotherapeutic Agents

Chemotherapeutic agents and antibiotics work with natural defense and stop the growth of bacteria and other microbes. e.g; sulfonamides, tetracycline, penicillin etc.
They destroy or inhibit the growth of microorganisms in living tissues.

- **Microbicidal** effect is one that kills the microbes immediately.
- **Microbistatic** inhibits the reproductive capacities of the cells and maintains the microbial population at constant size.

6.9.3 IMMUNIZATION AND VACCINATION

Methods of prevention and treatment that have been introduced to control microbial diseases include;

i) Immunization (e.g. vaccination)
ii) Antisepsis (procedures to eliminate or reduce the possibility of infection)
iii) Chemotherapy (use of antibiotics)
iv) Public health measures (e.g. water purification, sewage disposal, and food preservation).

Work of Louis Pasteur

- **Pasteur** made many discoveries concerning the cause and prevention of infectious diseases. In 1880's he ***isolated the bacterium responsible for chicken cholera.*** He grew it in a pure culture. To prove that he really had isolated the bacterium responsible for this disease **Pasteur** made use of the fundamental techniques devised by Koch. He arranged experiments for a public demonstration in which he repeated an experiment that had been successful in many previous trials in his laboratory.
- He inoculated healthy chicken with his pure cultures and waited for them to develop chicken cholera and die. But to his dismay, the chickens failed to get sick and die. Reviewing each step of the experiment, Pasteur found that he had accidentally used the cultures several weeks old instead of fresh one grown especially for the demonstration. He soon discovered that somehow bacteria could lose their virulence, or ability to produce disease, after standing and growing old. But these attenuated, or less virulent, bacteria could still stimulate the host (in this case the chicken) to produce antibodies, substances that protect the host (in this case the chicken) against infection due to subsequent exposure to the virulent organism.
- **Pasteur** next applied this principle of inoculation with attenuated cultures to the prevention of anthrax, and again it worked. He called the attenuated cultures of bacterial vaccine (a term derived from the Latin **Vacca** "cow") and immunization with attenuated cultures of bacteria, vaccination.

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- **Pasteur** honoured **Edward Jenner** (1749-1823), who had successfully vaccinated a boy against small pox in **1796**. **Jenner** had learned that milkmaids who contracted cowpox from the cows, they milked, never subsequently contracted the much more virulent small pox. Accordingly, he tested this hypothesis by inoculating young **James Phipps** first with cowpox causing material and later with small pox causing material. The boy did not get small pox.
- The **Pasteur** also made a vaccine for ***hydrophobia or rabies***. A disease transmitted to people by bites from rabid dogs, cats, and other animals.

QUESTION RELATED TO ABOVE ARTICLE

How are the microorganisms controlled? Explain the different method.
Write various methods to control bacteria. (GRW 2017, MTN 2019)
Discuss control of bacteria by physical and chemical methods. (GRW 2021)
Describe various physical and chemical method to control bacteria.
(DGK 2019 LHR 2021, MTN 2021, DGK 2021)
Why control of bacteria is necessary in home, industry and medical field? (MTN 2022)
How physical methods does differs from chemical methods to contral bacteria?
(FSD 2022)
Write an account on different methods used for controlling microbes.
(Exercise Question ii)

6.10 USE AND MISUSE OF ANTIVBIOTICS

Introduction

Antibiotics is a **Greek** word (Anti: against and Bios: life).

Definition

Antibiotics are the chemotherapeutic chemical substances which are used in treatment of infectious diseases.

Natural Source of Antibiotics

Antibiotics are synthesized and secreted by certain bacteria, e.g; actinomycetes and fungi.

Use antibiotics as prescribed by the physicians. Take dose at regular intervals and complete the treatment as advised by the doctor.

Artificial Source of Antibiotics

Today, some antibiotics are synthesized in the laboratory. However, their origins are living cells.

Precaution

To determine drug of choice, one must know its mode of action, possible adverse side effects in the human beings.

Hazards

Massive quantities of antibiotics are being prepared and used, which are followed by the widespread problems of drug resistance in microorganisms. This results in an increasing resistance against disease treatments.

Misuse of Antibiotics

Misused antibiotics can interact with the human metabolism and in severe cases can cause death of human beings.

- Misuse of antibiotic such as ***penicillin*** can cause ***allergic reactions***.
- Similarly, ***streptomycin*** can affect auditory nerve thus ***causing deafness***.
- ***Tetracycline*** and its related compounds caused ***permanent discoloration of teeth in young children.***

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QUESTION RELATED TO ABOVE ARTICLE

Explain the antibiotics and their misuse.

What do you know about miscues of antibiotics?

What are the use and misuse of antibiotics? (DGK 2021)

Why antibiotics are considered beneficial as well as harmful for human? (DGK 2022)

Discuss the role of antibiotics and immunization in controlling bacterial diseases.

What problem can arise due to misuse of antibiotics? (Exercise Question iii)

6.11 CHARACTERISTICS OF CYANOBACTERIA

Introduction

The cyanobacteria are the largest and most diverse group of photosynthetic bacteria which was previously known as ***blue green algae***.

Features

- Cyanobacteria are true prokaryotes. They vary greatly in shape and appearance.
- The range in diameter from about ***1-10 um*** and may be ***unicellular***, exist as ***colonies*** of many shapes, or form ***filaments*** consisting of ***trichomes*** (chains of cells) surrounded by mucilaginous sheath.
- They have normal ***Gram-negative type cell wall.***
- They lack flagella and often use ***gas vesicles*** to move in the water, and many filamentous species have ***gliding motility.***

Similarity with Photosynthetic Eukaryotes

- Their photosynthetic system closely resembles that of eukaryotes because they have chlorophyll and photosystem II.
- They carry out oxygenic photosynthesis. i.e, they use water as an electron donor and generate oxygen during photosynthesis.
- Cyanobacteria use ***phycobilins*** as accessory pigments. Photosynthetic pigments and electron transport chain components are located in thylakoid membranes linked with particles called ***phycobilisomes.***
- ***Phycocyanin*** pigment (blue) is their predominant phycobilins and CO_2 in them is assimilated through the Calvin cycle.
- Reserve food material in cyanobacteria is glycogen.

Reproduction

Cyanobacteria reproduce by binary fission, fragmentation. In cyanobacteria ***hormogonia, akinetes*** and ***heterocysts*** are present.

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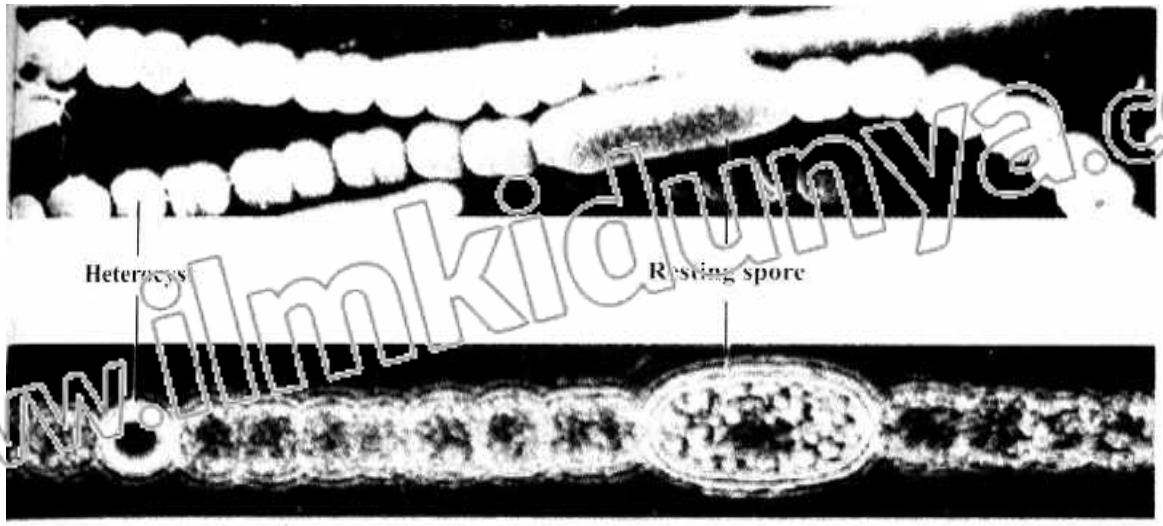


Fig. 6.8 Cyanobacterium Anabaena

11.1 ECONOMIC IMPORTANCE

- They help in ***reclamation of alkaline soils.***
- Cyanobacteria have heterocysts, which are helpful in the ***fixation of atmospheric nitrogen.***
- They ***release*** O_2 in the environment due to their photosynthetic activity.
- Oscillatoria and few other cyanobacteria can be used as ***pollution indicator.***
- They have ***symbiotic relationship*** with protozoa, fungi, and nitrogen fixing species form associations with angiosperms. They are photosynthetic partner in most of lichen association.
- ➢ Many species of cyanobacteria form ***water blooms*** where they often impart unpleasant smell and due to large amount of suspended organic matter water becomes unfit for consumption.
- ➢ Some species produce toxins that kill livestock and other animals that drink the water.

Super Blue green algae are basically expensive pond scum, in which cyanobacterium a singled celled organism is that produces its own food through photosynthesis. It serves as a "complete whole food "which contain 60% protein with all essential amino acids in perfect balance.

QUESTION RELATED TO ABOVE ARTICLE

Write down the characteristic of Cyanobacteria and its economic importance.
Describe characteristics of cyanobacteria. (LHR 2019)
Write down the characteristics and economic importance of cyanobacteria. (SWL 2019)
Give economic importance of Cyanobacteria. (GRW 2019, MTN 2019)
Discuss bacteria under the given headings. (LHR 2021, MTN 2021)
(i) Ecological importance (ii) Economic importance.
Give general character of cyanobacteria with special reference to *Nostoc*. (RWP 2021)
Compare photosynthesis in eubacteria and cyanobacteria with special reference to oxygen photosynthesis in cyanobacteria. (SGD 2022)

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6.11.2 NOSTOC

6.11.2. I HABITAT AND OCCURRENCE

- *Nostoc* is common as ***terrestrial*** and ***subaerial*** cyanobacterium.
- It is widely distributed in ***alkaline soils*** and on ***moist rocks*** and ***cliffs***. *Nostoc* forms a ***jelly like mass*** in which numerous filaments are embedded.

6.11.2. II STRUCTURE

- Trichomes are ***unbranched*** and appear ***beaded***. Individual cells are mostly ***spherical*** but sometimes barrel shaped or cylindrical.
- All cells in trichome are mostly similar in structure but at intervals are found slightly large round light ***yellowish thick-walled cells called as heterocysts.***
- Trichome mostly breads near heterocyst and forms ***hormogonia*** and thus help in fragmentation.

6.11.2. III REPRODUCTION

There is ***no sexual reproduction*** but it reproduces asexually by:

i) Formation of Hormogonia.

Hormogonia are formed when filament break at different points into smaller pieces. This is due to death and decay of an ordinary cell or the heterocyst may server as a breaking point.

ii) Formation of Akinetes

Reproduction can also be due to akinetes formation. Akinetes are thick walled, enlarged vegetative cells which accumulate food and become ***resting cells.*** On arrival of favorable conditions, they form normal vegetative cell.

QUESTION RELATED TO ABOVE ARTICLE

Describe habitat and reproduction in *Nostoc*.

Explain the general characteristics of cyanobacteria with special reference of *Nostoc*.

Describe structure and reproduction in *Nostoc*. (LHR 2018)

Describe general characteristics of Cyanobacteria with special reference to *Nostoc*.

(Exercise Question iv)

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KEY POINTS

Gram positive and Gram negative bacteria:

It is a method of staining bacteria. There are two stains for the staining of bacteria. Primary stain is purple or **violet dye**. It is also called Gram's dye. T is secondary is red dye **eosin.** Following method is uses for staining.

1. Bacteria are stained with purple dye. Their colour becomes purple.

2. Now these bacteria are treated with alcohol. The gram positive bacteria retain purple colour and do not change their colour. On the other hand gram negative bacteria lose the purple colour and become colourless. So the gram positive bacteria retain the primary stain.

3. The gram negative bacteria disappear and cannot be seen. So they are treated with secondary dye eosin. They become pink or red and reappear. So gram negative lose primary satin but are stained with secondary strain.

Chemosynthetic bacteria:

These bacteria oxidize (remove electron) the inorganic compounds like ammonia, ferric

$$Fe^{+3} \longrightarrow Fe^{+2} + e^{-}$$

These electrons are used for obtaining energy.

Lichens:

It is symbiotic association between algae and fungi. Cyanobacteria or blue green algae can also develop this association with fungi.

Water Bloom:

Sometimes, cyanobacteria grow on standing water of ponds and completely cover its water, it is called water bloom.

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EXERCISE

Q.1.

Fill in the blanks

i) A bacterial arrangement in packets of eight cells is described as a _____.

ii) The shape and arrangement of _____ is diplococci.

iii) Pili are tubular shafts in bacteria that serve as a means of _____.

iv) _____ are unusual type of bacteria that live in extreme habitats.

v) _____ is a bacterium that is photosynthetic.

vi) _____ is a cyanobacterium.

vii) _____ are called as bloom forming organism.

viii) Use of antibiotics is one of the means of controlling _____ diseases.

Ans:

i) Sarcina
ii) Two cocci
iii) Attachment
iv) Endospore forming
v) Green sulphur bacteria
vi) Nostoc
vii) Nostoc
viii) Infectious

Q.2. Each question has four options.
Encircle correct answer.

i) Which of the following is not found in all bacterial cells?
(a) Cell membrane **(b)** Ribosomes
(c) A nucleoid **(d) Capsule**

ii) The major locomotory structure in bacteria are:
(a) Flagella **(b)** Fimbriae
(c) Pilli **(d)** Cilia

iii) Which of the following is a primary bacterial cell wall function:
(a) Transport **(b) Support**
(c) Motility **(d)** Adhesion

iv) Which of the following is present in both Gram positive and Gram-negative cell wall?
(a) An outer membrane
(b) Peptidoglycan
(c) Techoic acid
(d) Lipopolysaccharides

v) Mesosome are internal extensions of the:
(a) Cell wall
(b) Cell membrane
(c) Chromatin body
(d) Capsule

vi) Bacterial endospore function in:
(a) Reproduction
(b) Protein synthesis
(c) Survival
(d) Storage

Answers Key:

i	**d**	**vi**	**c**
Ii	**a**		
iii	**b**		
iv	**b**		
v	**b**		

Q.3. Short Questions

i) (a) Name general characteristics that could be used to define prokaryotes.
(b) Do any other microbial group besides bacteria have prokaryotic cells?
(c) In what habitats are bacteria found? Give some general means by which bacteria derive nutrients.

Ans:

(a) No definite nucleus, absence of membrane bounded organelles, cell wall made of Murein and small sized ribosomes.
(b) Yes, Cyanobacteria
(c) Bacteria usually occur in all habitats ranging from extreme hot conditions to cold glaciers. There are two common general means of nutrition in bacteria i.e heterotrophic and autotrophic.

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ii) (a) List functions that the cell membrane performs in bacteria.
(b) What are mesosomes and some of their possible functions?

Ans:
(a) Regulates transport of material and contains enzymes for respiratory metabolism
(b) It is an invagination of cell membrane in bacteria and is involved in cell division.

iii) What is unique about the structure of bacterial ribosomes?

Ans: Bacterial ribosomes are of small sized with 70S.

iv) Draw the three bacterial shapes.

Ans:



Cocci



Bacilli



Spirochete

v) Name a bacterium that has no cell wall.

Ans: Mycoplasma bacteria are without cell wall.

vi) A gram stain discharge from an abscess shows cocci in irregular grape-like clusters. What is the most likely genus of this bacterium?

Ans: Genus of this bacterium will be staphylococci.

vii) Draw an outline and label
(i) Streptobacilli
(ii) Diplococci
(iii) Staphylococci

Ans :



Streptobacilli



Staphylococci



Diplococci

viii) You observe a culture of predominantly round (presumably spherical) bacteria that though apparently fully divide, nevertheless have failed to separate, thus resulting in long chains of cells. What, generally, might you call such an arrangement?

Ans: Streptococci

i) Match the following description with the best answer.

(a) Division in one plane; cocci arranged in pairs	**(a)** Bacillus	Diplococcus
(b) Division in one plane; cocci arranged in chains	**(b)** Streptobacillus	Streptococcus
(c) Division in two planes; cocci arranged in square of four	**(c)** Spirochete	Tetrad
(d) Division in one plane; rods completely separate after division	**(d)** Spirillum	Bacillus
(e) Division in one plane; rods arranged in chains	**(e)** Vibrio	Streptobacillus
(f) A comma shaped bacterium	**(f)** Streptococcus	Vibrio
(g) A thin, flexible spiral	**(g)** Staphylococcus	Spirillium
(h) A thick, rigid spiral	**(h)** Diplococcus	Spirochete
	(i) Tetrad	
	(j) Sarcina	

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Q.4. Extensive Questions.

i) Describe in detail the structure of bacterial cell wall, emphasizing on Gram positive and Gram negative properties.

Ans: (See article 6.4.5)

ii) Write an account on different methods used for controlling microbes.

Ans: (See article 6.9)

iii) Discuss the role of antibiotics and immunization in controlling bacterial diseases. What problem can arise due to misuse of antibiotics?

Ans: (See article 6.9.3 & 6.10)

iv) Describe general characteristics of Cyanobacteria with special reference to Nostoc.

Ans: (See article 6.11)

v) Write notes on:

(a) Koch's postulates

Ans: (See article 6.2)

(b) Shape of bacteria

Ans: (See article 6.4.2)

(c) Flagella and pilli

Ans: (See article 6.4.3)

(d) Growth in bacteria

Ans: (See article 6.7)

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