3. Bacteria

Introduction

In 1676 **Anton Van Leeuwenhoek** discovered the microbial world by his simple microscope. It was only after the invention of compound microscope by **Hooke** in 1820, that bacteria came to lime light. These very minute creatures were designated as "small microscopic species" or " **Infusorial animalcules**". **Louis pasteur**(1822-95) made a detailed study of bacteria and proposed **germ theory of disease. Robert Koch,** a german microbiologist, was the first scientist to prove the cause and effect relationship between microbes and animal diseases. **Ehrenberg**(1829) was the first to use the term **bacterium**. The branch of study that deals with bacteria is called **Bacteriology**. Bacteria are unicellular organisms and they are prokaryotic. i.e they do not have a membrane bound nucleus and membrane bound organelles .

Occurrence

Bacteria are omnipresent. They are found in all environments, where organic matter is present. They are found in air, water, soil and also in or on the bodies of plants and animals. Some of the bacteria live as **commensals** (eg. **Escherichia coli** in the human intestine) and some live as **symbionts** (eg. **Rhizobium**) in the root nodules of leguminous plants. Several of them cause diseases in plants, animals and human beings.

Size

Bacteria are very small, most being approximately 0.5 to 1 micron in diameter and about 3 to 5 microns in length.

Classification of bacteria based on the shape and arrangement

The rigid bacterial cell wall determines shape of a cell. Typical bacterial cells are spherical (**Cocci**), straight rods (**Bacilli**) or rods that are helically curved (**spirilla**), some bacterial cells are **pleomorphic** ie they can exhibit a variety of shapes eg. ***Arthrobacter***

Cocci bacteria appear in several characteristic arrangements depending on their plane of division.

A. **Diplococci:** Cells divide in one plane and remain attached in pairs.

B. **Streptococci:** cells divide in one plane and remain attached to form chains.

C. **Tetracocci**: Cells divide in two planes and form group of four cells.

D. **Staphylococci:** cells divide in three planes, in an irregular pattern, producing bunches of cocci.

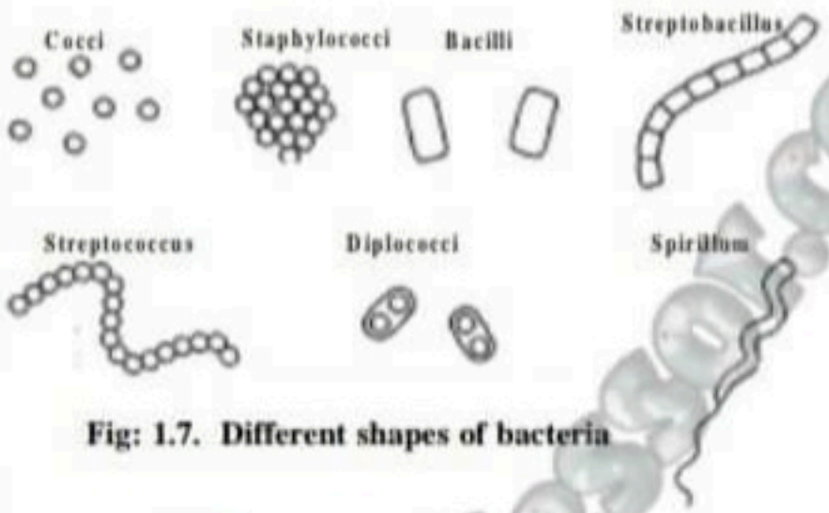

Fig: 1.7. Different shapes of bacteria

E. **Sarcinae:** cells divide in three planes, in a regular pattern, producing a **cuboidal** arrangement of cells.

Bacilli forms occur singly or in pairs (**diplobacilli**) or form chains (**streptobacilli**). In ***Corynebacterium diphtheriae*** which is a bacillus species, the cells are arranged side by side like match sticks (**palisade** arrangement)

Flagellation in Bacteria

All spirilla, about half of the bacilli and a small number of cocci are flagellated. Flagella vary both in number and arrangement according to two general patterns.

1. In a **polar arrangement**, the flagella are attached at one or both the ends of the cell. Three sub types of this pattern are:

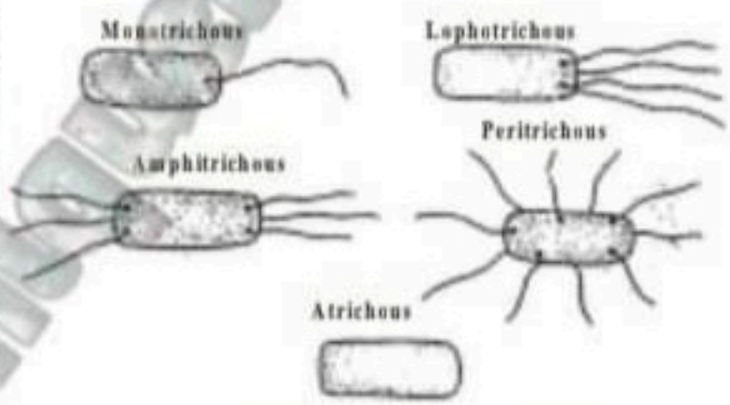

Fig: 1.8. Flagellar arrangement in Bacteria

a. **monotrichous** – with a single flagellum
b. **lophotrichous** – with small bunches or tufts of flagella emerging from one end
c. **amphitrichous** – with flagella at both poles of the cell

2. In a **peritrichous** arrangement flagella are dispersed randomly over the surface of the cell.
3. **Atrichous** bacteria lack flagellum.

Flagellar Functions

They can detect and move in response to chemical signals – a type of behaviour called **chemotaxis.** Positive chemotaxis is movement of cell in the direction of a

favourable chemical stimulus (usually a nutrient). Negative chemotaxis is movement away from a repellant (potentially harmful) compound.

Nutrition in Bacteria

Autotrophic Bacteria

Some bacteria can synthesize their food and hence they are autotrophic in their mode of nutrition. They may be **photo autotrophs** (eg. **Spirillum)** or **chemoautotrophs** eg. ***Nitrosomonas*** or ***Nitrobacter.***

Photoautotrophic bacteria

They use sunlight as their source of energy to synthesize food. But unlike photosynthetic eukaryotic cells they do not split water to obtain reducing power. So Oxygen is not evolved during bacterial photosynthesis. Depending upon the nature of the hydrogen donor these bacteria may be

1. Photolithotrops

In this the hydrogen donor is an inorganic substance. In green sulphur bacteria(eg. ***Chlorobium*)** hydrogen sulphide (H_2s) is the hydrogen donor. The chlorophyll is **bacterioviridin**

In purple sulphur bacteria (eg. ***Chromatium***) thiosulphate acts as hydrogen donor. The chlorophyll is **bacteriochlorophyll.**

2. Photo-organolithotrophs

In this the hydrogen donor is an organic acid or alcohol eg. Purple non sulphur bacteria (eg. ***Rhodospirillum***)

Chemoautotrphic bacteria

They do no have photosynthetic pigments and hence they cannot use sunlight energy. Instead they obtain energy in the form of ATP by oxidising inorganic or organic compounds. The energy thus obtained is used to reduce CO_2 to organic matter. Based on the type of substance oxidized they may be

1. **Chemolithotrophs:** Inorganic compound is oxidized to release energy. eg. Sulphur bacteria (eg. ***Thiobacillus*)**

   Iron bacteria (eg. ***Ferrobacillus***), Hydrogen bacteria eg. ***Hyderogenomonas*** and Nitrifying bacteria (eg ***Nitrosomonas*** and ***Nitrobacter*)**

2. **Chemo – organotrophs**: In this type it is an organic compound that is oxidized to release energy. eg. Methane bacteria (***Methanococcus***).

Acetobacteria and ***Lactobacillus*** are also examples for chemo-organotrophs.

Heterotrophic Bacteria

They depend upon other organisms (living/dead) for their food since they cannot synthesize their own food. They may be saprotrophic e.g (***Bacillus subtilis***), parasitic e.g. Plant parasite-(***Xanthomonas citrii***) animal parasite e.g.(***Bacillus anthracis***) , Human parasite e.g (***Vibrio cholerae***) or symbiotic in association with roots of the family **Leguminosae**. e.g. **(Rhizobium)**

Respiration in Bacteria

Aerobic Bacteria: These bacteria require oxygen as terminal acceptor of electrons and will not grow under anaerobic conditions(i.e in the absence of O_2) Some micrococcus species are **obligate aerobes** (i.e they must have oxygen to survive)

Anaerobic bacteria : These bacteria do not use oxygen for growth and metabolism but obtain their energy from fermentation reaction. eg. ***Clostridium* species**.

Capnophilic bacteria are those that require CO_2 for growth.

Facultative anaerobes: Bacteria can grow either oxidatively using oxygen as a terminal electron acceptor or anaerobically using fermentation reaction to obtain energy. Bacteria that are facultative anaerobes are often termed "**aerobes**". When a facultative anaerobe such as E. Coli is present at a site of an infection like an abdominal abscess it can rapidly consume all available O_2 and change to anaerobic metabolism, producing an anaerobic environment and thus, allow the anaerobic bacteria that are present to grow and cause disease.

Endospores are structures formed in bacillus bacteria during unfavourable conditions. Fortunately most pathogenic bacteria (except tetanus and anthrax bacteria) do not form endospores.