Prokaryotic cell:

The bacteria (singular bacterium) are amongst the smallest organisms. They are most primitive, simple, unicellular and microscopic organisms. Bacteria occur almost everywhere : in air, water, soil and inside other organisms. They show high metabolic rate because they absorb their nutrients directly through cell membranes.

1. Size of bacteria. Typically bacteria range between 0.2µm (one micrometre) to 5 µm, so they are barely visible under the light microscope.The smallest bacteria (mycoplasma),the longest bacteria rods are the size is (7 µm).

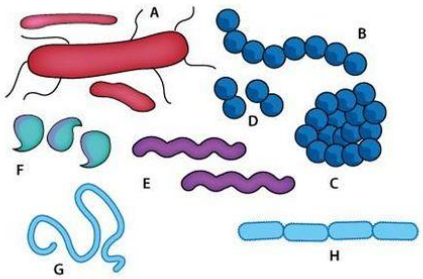
2. Forms of bacteria. Bacteria vary in their shapes. Based on their shape, bacteria are classified into the following groups :

(1) Cocci (singular coccus). These bacteria are spherical or round in shape.(*Staphylococcus aureus).*

(2) Bacilli (singular, bacillus). These are rod-like bacteria. (*Mycobacterium* or*Bacillus tuberculosis*).

(3) Spirilla (singular, spirillum). These are also called **spirochetes**. These are spiral-shaped and motile bacteria

(4) Vibrios (singular vibrio). These are comma-shaped or bent-rod like bacteria. Vibrios cause human disease such as cholera (*Vibrio cholerae*).



(5) Pleomorphic (many shaped) they are variable in shape and size.

3. Gram negative and Gram positive bacteria. On the basis of structure of cell wall and its stainability with the Gram stain, the following two types of bacteria have been recognized : Gram positive and Gram negative bacteria.

4. Structure of bacteria. A typical bacterial cell has the following components:

A. Outer covering. The outer covering of bacterial cell comprises the following three layers:

I. Plasma membrane. The bacterial protoplast is bound by a living, ultrathin (6 to 8 nm thick). The plasma membrane chemically comprises molecules of lipids and proteins which are arranged in a **fluid mosaic pattern**. That is, it is composed of a bilayer sheet of **phospholipid** molecules with their polar heads on the surfaces and their fatty-acyl chains (tails) forming the interior. The **protein** molecules are embedded within this lipid bilayer, some spanning it, some exist on its inner side and some are located on its external or outer side. These membrane proteins serve many important functions of the cell.

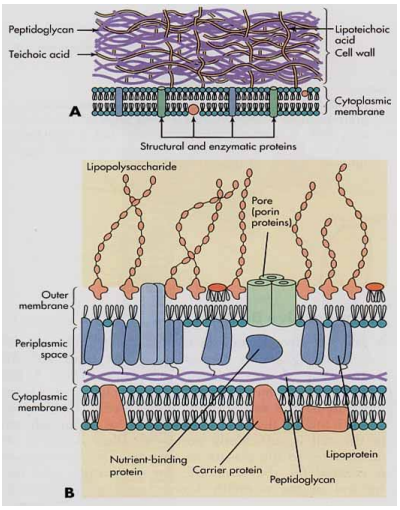
For example,

1. the transmembrane proteins act as **carriers** or **permeases** to carry on selective transportation of nutrients (molecules and ions) from the environment to the cell or vice versa.

2.Certain proteins of the membrane are involved in oxidative metabolism, *i.e.*, they act as enzymes and carriers for electron flow in respiration and photosynthesis leading to phosphorylation (*i.e.*, conversion of ADP to ATP).

3. The bacterial plasma membrane also provides a specific site at which the single circular chromosome (DNA) remains attached. It is the point from where DNA replication starts. The first stage in nuclear division involves duplication of this attachment.

II. Cell wall. The plasma membrane is covered with a strong and rigid cell wall that renders mechanical protection and provides the bacteria their characteristic shape . The cell wall of bacteria contains proteins, lipids and polysaccharides.



III. Capsule. In some bacteria, the cell wall is surrounded by an additional slime or gel layer called **capsule**. It is thick, gummy, mucilaginous and is secreted by the plasma membrane. The capsule serves mainly as a protective layer against attack by phagocytes and by viruses. It also helps in regulating the concentration, and uptake of essential ions and water.

B. Cytoplasm. The plasma membrane encloses a space consisting of **matrix** or **cytosol** which is the ground substance and the seat of all metabolic activities. The cytosol consists of water, proteins (including multifunctional enzymes), lipids, carbohydrates, different types of RNA molecules, and various smaller molecules .In the cytoplasm occur thousands of particles, called **ribosomes**.

Ribosomes are composed of ribonucleic acid (RNA) and proteins and they are the sites of protein synthesis.

During protein synthesis many ribosomes read the codes of single mRNA (messenger RNA) molecules and form **polyribosomes** or **polysomes**.

Reserve materials of bacteria are stored in the cytoplasm either as finely dispersed or distinct granules called **inclusion bodies** or **storage granules**. There are three types of reserve materials.

First, there are organic polymers which either serve as reserves of carbon , or as stores of energy, as does a polymer of glucose, called **granulose** (*i.e.*, glycogen).

Second, many bacteria contain large reserves of inorganic phosphate.

The third type of reserve material is elemental **sulphur**.It occurs as an energy reserve in the form of spherical droplets in certain sulphur bacteria.

C. Nucleoids. In bacteria the nuclear material includes a single, circular and double stranded DNA molecule which is often called **bacterial chromosome**. It is not separated from the cytosol by the nuclear membranes as it occurs in the eukaryotic cells. However, the nuclear material is usually concentrated in a specific clear region of the cytoplasm, called **nucleoid**. A nucleoid has no ribosome and nucleolus. The bacterial chromosome is permanently attached to the plasma membrane at one point. All three classes of RNA (*i.e.*, mRNA, tRNA, and rRNA) are formed (transcribed) by the activity of the single RNA polymerase (RNAP) species in prokaryotes.

Plasmids. Many species of bacteria may also carry extrachromosomal genetic elements in the form of small, circular and closed DNA molecules, called **plasmids** which carry genes for the resistance to one or more drugs such as chloramphenicol, neomycin, penicillin, streptomyocin, sulphonamides and tetracyclines.

D. Flagella and other structures. Many bacteria (*e.g.*, *E. coli*). are motile and contain one or more **flagella** for the cellular locomotion (swimming).

E . Fimbriae or pili. Some bacteria (mostly Gram negative bacilli) contain non-flagellar, extremely fine, appendages called **fimbriae** or **pili** (singular **pilus**). Pili are non- motile but adhesive structures. They enable the bacteria to stick firmly to other bacteria, to a surface or to some eukaryote such as mold, plant and animal cells including red blood cells and

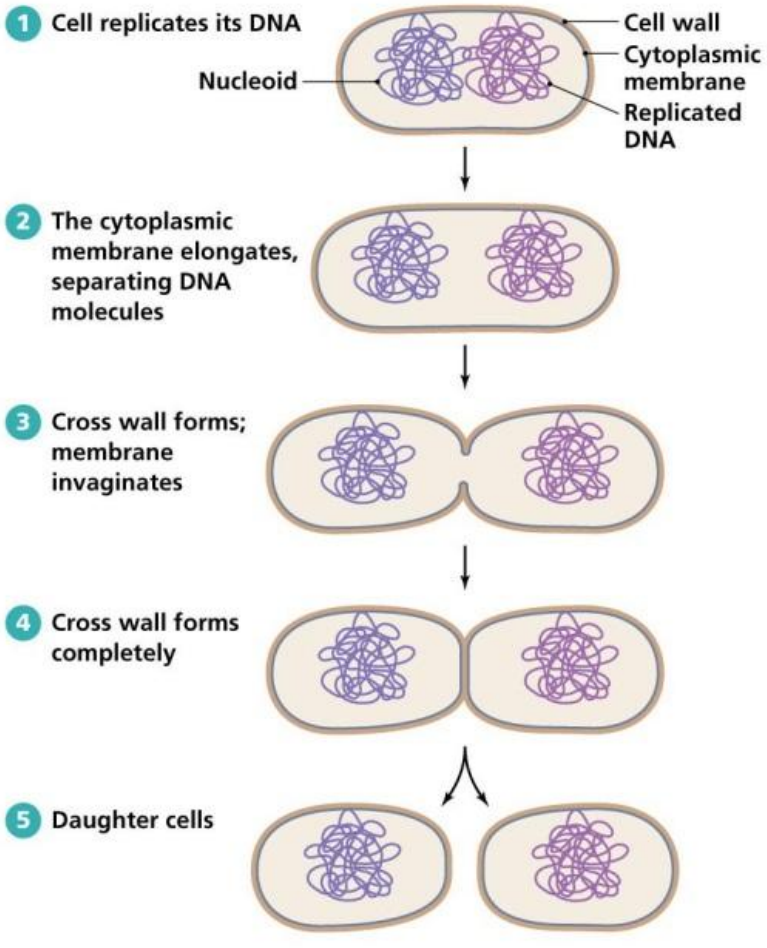
epithelial cells of respiratory and urinary tracts. Pili are known to be coded by the genes of the plasmid.

5. Nutrition in bacteria. Bacteria show wide diversity in their nutrition. Some are chemosynthetic, some are photosynthetic, but most of them are heterotrophic. Heterotrophic bacteria are mostly either saprophytic or parasitic. Parasitic bacteria live on the body of plants and animals and with few exceptions, most bacteria are pathogenic . Modes of respiration of bacteria are both aerobic and anaerobic.

6. Reproduction in bacteria. Bacteria reproduce asexually by **binary fission** and **endospore** formation and sexually by **conjugation**. In the binary fission, the cell divides into two genetically identical daughter cells. During this process, the single circular chromosome first makes a copy of itself (*i.e.,* it duplicates) and daughter chromosomes become attached to the plasma membrane. They separate as the bacterial cell enlarges and ultimately the formation of a cross wall between the separating daughter chromosomes, divides the parent cell into two daughter cells.

Under unfavorable ecological conditions, many bacteria (*e.g., Clostridium, Bacillus,* etc.) form spores which are not reproductive units but represent an inactive state. In endospore formation, a part of the protoplasmic material is used to form an impermeable coat or cyst wall around the chromosome along with some cytoplasm. The rest of the cell degenerates. The spore being metabolically inert can survive an unsuitable temperature, pH and drought. Under favourable conditions, spores imbibe water, become metabolically active again and germinate.

Bacterial conjugation is simplest form of sexual reproduction known. During the process of conjugation, a F+ or donor bacterium (equivalent to male) passes a piece of DNA or plasmid containing fertility or F gene to the F $^{-}$ or recipient bacterium (equivalent to female). The donor's plasmid passes through the sex pilus of donor cell to the recipient. Following the conjugation, the progenies of the recipient express some of the characteristics of the donor. Thus, bacterial conjugation is a means of making new genetic combinations or recombination which are expressed in the progeny.



FORMATION OF ENDOSPORES