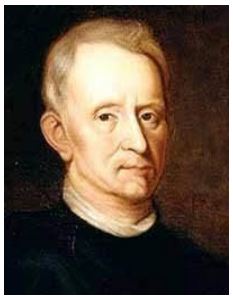
Introduction to Cell Biology

(**Cell:** Latin- Cella= Small room or small container)

The cell is the smallest unit of life. All living organisms are composed of single or many cells (Unicellular and Multicellular).



Robert Hooke (1665) discovered cells while examining a piece of cork under magnifying lenses. He found that cork was made of small chambers surrounded by walls. He called these chambers as cells. This was the beginning of a new branch of biology ie. **cell biology** or **Cytology.**

Thereafter, over the next 175 years, several kinds of research were made which led to the formation of the cell theory that we know today.

"Cell Biology is a scientific discipline that studies cells– their physiological properties, structure, the organelles they contain, interactions with their environment, their life cycle, division and death."

What are cells?

"Cell is the basic structural and functional unit of living organism."

In all the living beings, cells are the basic structural units. We can compare the presence of cells in our body to the bricks in a building. All the bricks are assembled to make a building. Similarly, all the cells are assembled to make the body of an organism.

Thus, it is the basic structural and functional unit of life and all the organisms are made up of cells. The subcellular structures of the cell comprise of the plasma membrane, organelles and in some cases a nucleus as well. As for the size of the cell, it is variable and maybe anything from 1 to 100 micrometre.

Cell Theory

- The cell is the basic functional and structural unit of life. All the living organisms are composed of cells.
- All cells are formed by the division of the already existing cells which in terms of biology means reproduction. Every cell of our body comprises of genetic material which is passed down during the process.
- All the basic physiological and chemical functions i.e. the growth, repair, movement, communication, immunity and digestions are performed inside the cells.
- All the activities of the cell depend mainly on the activities of the subcellular structures that lie within the cell. These subcellular structures comprise of the plasma membrane, organelles and if present, the nucleus.

Importance of Cell Biology:

- To understand the difference between living and non-living.
- It encompasses the great diversity of single celled organisms (bacteria and protozoa) as well as multicellular organisms (animals, plants, fungi).
- Research in cell biology is closely related with genetics, biochemistry, molecular biology, immunology, developmental biology, tissue culture, biotechnology and microbiology.
- It helps biologists to understand various life processes like- growth, metabolism, differentiation etc.
- Cell biology has given birth to various applied branches like- cytogenetics, cytotaxonomy, cell physiology, cytochemistry, molecular biology, cytoecology, cytopathology etc.
- These branches have tremendous applications in the field of agriculture and medicine.

Scope of cell Biology:

Cell biology has a number of applications in various branches of life science.

1. Cytogenetics
2. Cytotaxonomy
3. Cell physiology
4. Cytopathology
5. Cytochemistry
6. Cyto-ecology
7. Molecular biology
8. Cell culture

1. Cytogenetics:

It is a branch of cytology dealing with the cytological and molecular basis of heredity, variation, phylogeny, morphogenesis, differentiation and evolution of chromosomal behaviour of organisms.

Knowledge of cytogenetics is important in the identification and synthesis of hereditary material, cracking the genetic code, hybridisation for the development of better-quality crops.

The study of cytogenetics try to provide answers to the problems of inheritance of parental characters, origin of heritable variations etc. It has practical applications in the field of plant breeding, animal breeding and medical science.

Thus, cytogenetics helps in the study of various aspects of organisms on the basis of the behaviour of its nuclear material.

2. Cytotaxonomy:

It is the branch of biology which includes study of relationships and classification of organisms using the comparative study of their chromosomal content.

Every species of plant and animal possess definite set of chromosomes in their nucleus.

These chromosomes give unique shape, size, habitat and behavioural characteristics to each and every species.

These chromosomal characteristics are very useful in determining taxonomic position of the organism. This attribute of cell biology is studied in cytotaxonomy.

3. **Cell physiology:**

Physiology is the study of functions and processes.

Cell physiology deals with the study of life activities such as nutrition, metabolism, growth, reproduction (cell division) and cell differentiation.

It has helped in understanding various complicated physiological activities at cellular level. This knowledge helps in understanding various normal and abnormal physiological activities.

4. **Cytopathology:**

It deals with the study of diseases that are caused due to abnormal activities of cells and tissues. This includes study of cancer cells, effects of viruses on cell structure and function. It also studies effect of toxic chemicals on the cells.

It shows close relationship between cytology, pathology as well as medicine. Thus, it is important in understanding different diseases of animals.

5. **Cytochemistry:**

It is the branch of cell biology concerned with the study of physico-chemical and chemical composition of living matter.

The cytochemical analysis indicates the presence of carbohydrates, proteins, lipids, nucleic acids (DNA & RNA) and other organic and inorganic components in the cells.

Introduction to Cells

Each and every plant and animal is made of a cell or cells. Cells are building blocks of organisms.

"A cell is a basic structural and functional unit of an organism."

Loewy and Siekevitz (1963) defined a cell as "a unit of organism delimited by a plasma membrane and capable of self-reproduction."

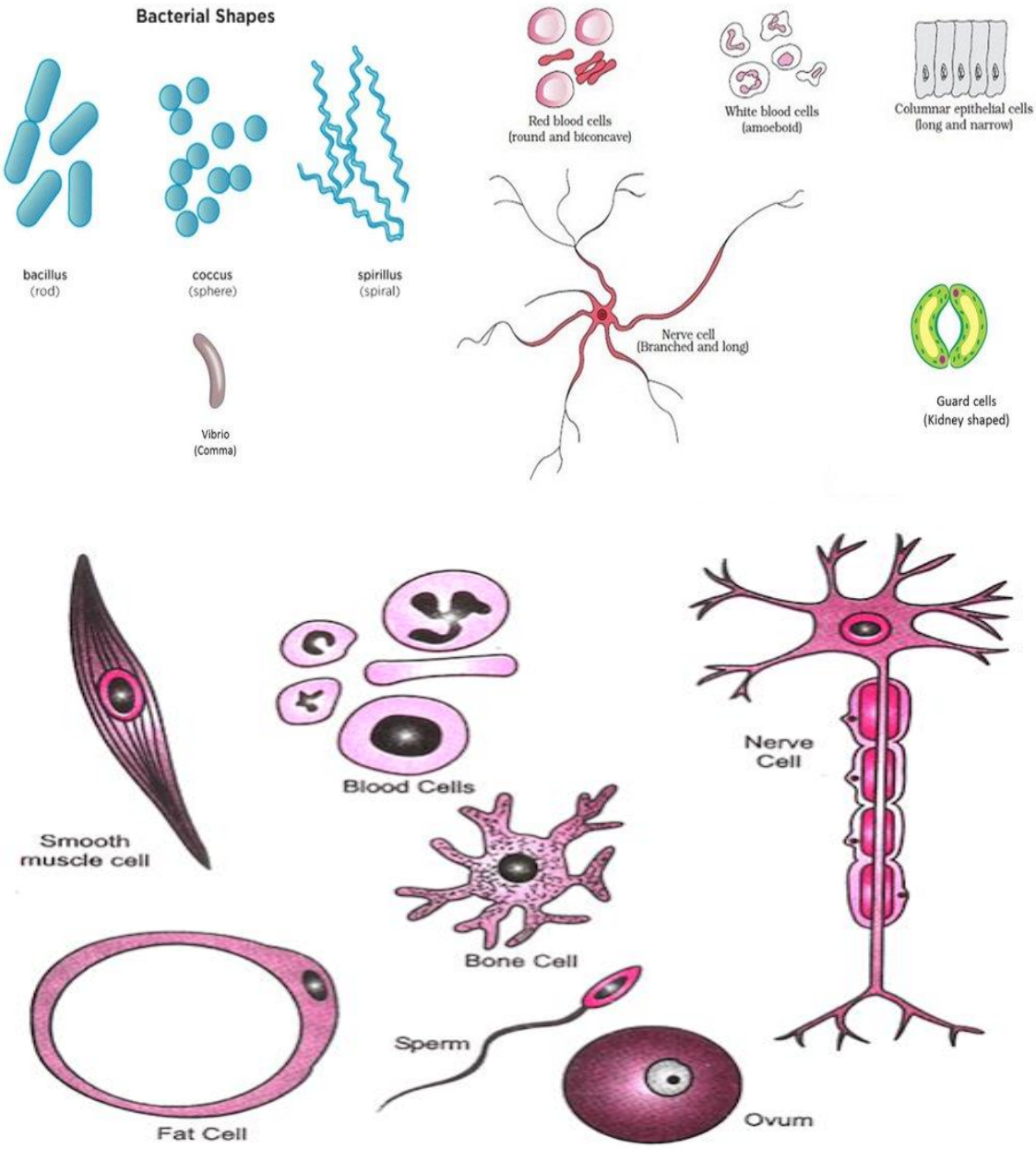
Size of Cells:

Most of the cells are microscopic in size. The size of cells varies from- 0.1µ to 1,705, 000µ (175mm). The smallest cells are of *Mycoplasma gallisepticum* (Bacterium)- 0.1µ in diameter. The egg of ostrich is usually considered as the largest cell which is about 175mm in diameter. The muscle cells and nerve cells of man are the longest cells (3.5 feet in length).

Shape of Cells:

Cells exhibit various forms and shapes. A cell is typically spherical in shape.

Certain cells are irregular, tubular, triangular, cuboidal, cylindrical, rounded, oval, flat, discoidal, elongated etc. The shape of the cells may vary from organism to organism and from organ to organ..



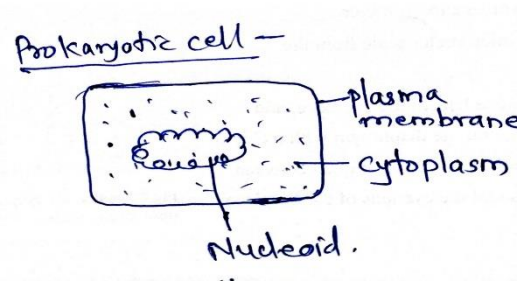
Types of Cells

<u>There are two types of cells based on their nature:</u>

1. Prokaryotic Cells: (Gr. Pro= primitive; Karyon= nucleus)
   Relatively simple cells - lack nuclear membrane and many organelles - bacteria and their relatives are all prokaryotic.

2. Eukaryotic Cells: (Gr. Eu= good or well; Karyon= nucleus)
   More complex cells, have a nucleus with nuclear membrane and many organelles. All cells of plants, animals, fungi and protista.

1. Prokaryotic Cells:

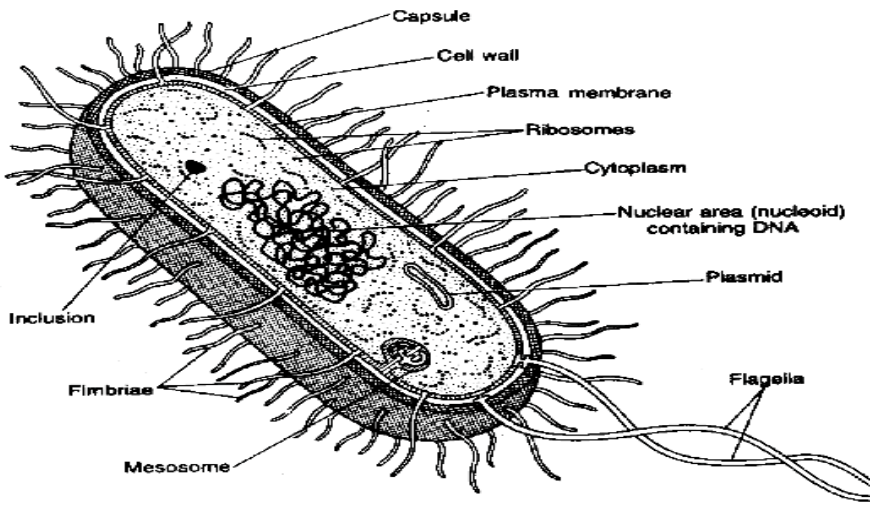


The prokaryotic cells are small, simple and most primitive. These cells are having primitive nucleus which lacks nuclear membrane and nucleolus. In these cells the hereditary material (Nuclear material) is not surrounded by nuclear membrane. It is in the form of naked circular coil of DNA in direct contact with cytoplasm. Such nuclear material without nuclear membrane is called as **Nucleoid.**

These cells do not possess membrane bound cell organelles. These cells are surrounded by a Plasma membrane like that of eukaryotic cells. Plasma membrane is surrounded by a cell wall. The cell is filled with cytoplasm. Cytoplasm contains ribosomes which are smaller and 70S type. They contain a single chromosome which is smaller and circular.

The chromosome is formed of double stranded DNA and composed of DNA only, protein is absent. E.g. ***E. Coli,*** Blue green algae

Escherichia coli



E. coli is a unicellular colon bacterium, occurring in the lower intestine of man. This bacterium is about 2µm long and 1µm in width. It is rod shaped and Gram-negative bacteria.

It mainly consists of: Cell Wall, Plasma membrane, Cytoplasm, Mesosomes, Appendages, Coils of DNA, Ribosomes and Various inclusions.

Cell wall:

A bacterium cell wall is made up of complex structure of polysaccharides. It is rigid and provides mechanical protection. It provides definite shape and gives strong support.

Plasma Membrane:

It is present below the cell wall. It is innermost covering of cell and mainly composed of lipids and proteins

Cytoplasm:

Cytoplasm is present inner to plasma membrane. It is a semifluid substance or matrix. It contains variety of organic and inorganic compounds

Mesosomes:

The cell membrane is folded inwards at some places to form a structure called mesosomes. The mesosomes are involved in the respiratory processes.

Nucleoid:

The bacterium shows a nucleus like structure in the center of cell called nucleoid. In the nucleoid a single, circular, large and highly folded DNA is present. In addition to this, a small, circular DNA is present called Plasmid.

Plasmids are responsible for resistance to antibiotics and other toxic materials. They are now used as important tools in rDNA technology.

Ribosomes:

Cytoplasm contains dense particles called ribosomes. They are made up of RNA and proteins. Prokaryotic cells contain '70S' type ribosomes. They help in protein synthesis.

2. Eukaryotic Cells:

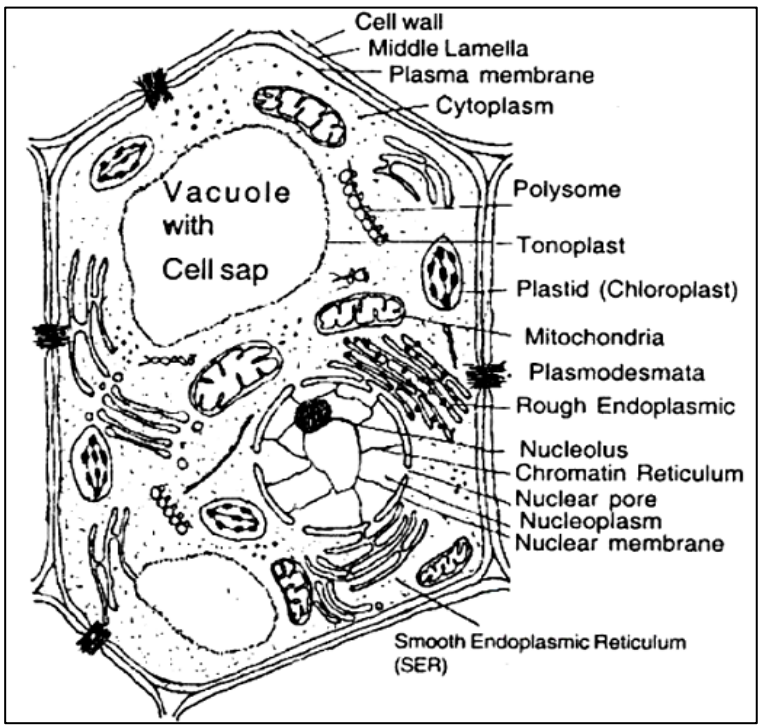
"The Cells containing true nucleus are called eukaryotic cells."

i.e., the nuclear material (chromatin) remains separated from cytoplasm by thin nuclear membrane.

These cells occur in higher forms such as fungi, plants and animals. They are much bigger than prokaryotic cells. These cells vary in shape, size, organelle composition and their physiological roles. All these cells are typically composed of- plasma membrane, true nucleus, cytoplasm and membrane bound organelles. The chromosomes are composed of DNA and basic proteins (histones).

Some eukaryotic cells bear locomotory structures like pseudopodia, flagella, cilia etc.

Plant Cell:



A typical plant cell consists of:

- Cell wall
- Plasma membrane
- Cytoplasm
- Nucleus
- Different membrane bound organelles-
  - Endoplasmic reticulum
  - Golgi complex
  - Mitochondria
  - Ribosomes
  - Vacuoles
  - Chloroplasts

Cell wall:

The rigid and protective, semi-transparent covering outside the cell membrane is called cell wall. It is absent in animal cells. It is mainly composed of Cellulose. The cell wall is thick, strong and rigid, thus gives definite shape, protection and provides mechanical support to the cell.

Plasma Membrane:

It is thin, semi-permeable, non-granular and continuous. It is present both in plant and animal cells. In plant cells it is present inner to the cell wall. It surrounds the cytoplasm of the cell.

It gives mechanical support and external shape to protoplasm. It also checks the entry and exit of substances to and from the cells.

Cytoplasm:

The space between plasma membrane and nucleus is filled with cytoplasm. The aqueous phase of cytoplasm excluding cell organelles is called Cytosol. It is a colourless, homogenous, transluscent, amorphous & colloidal fluid.

It is composed of various molecules such as water, salts of NA, K & other metals. The organic compounds such as carbohydrates, lipids, proteins, nucleic acids & enzymes are present. Many cell organelles remain suspended in cytoplasmic matrix.

Nucleus:

In plant cells a well distinct and true nucleus is present. Nucleus is the controlling centre of the cell.

It Controls & regulate various metabolic activities of the cells. It act as a vehicle for transmission of hereditary characters through chromosomes.

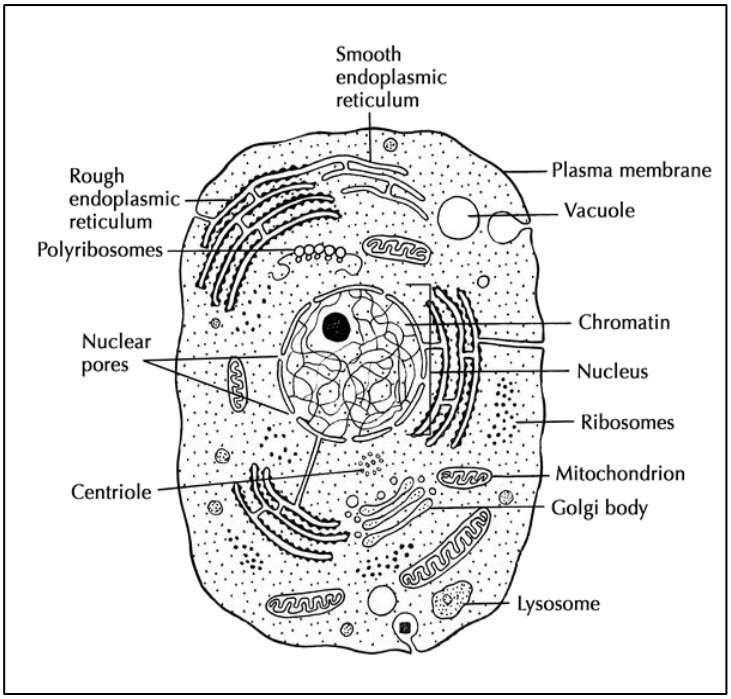
Cell organelles:

Many cell organelles remain suspended in cytoplasmic matrix like-Endoplasmic reticulum, Ribosomes, Golgi complex, Mitochondria, Vacuoles, Chloroplasts, Lysosomes etc.

Animal Cell:

A typical Animal cell consists of:

- Plasma membrane
- Cytoplasm
- Nucleus
- Different membrane bound organelles- Endoplasmic reticulum, Golgi complex, Mitochondria, Ribosomes, Lysosomes, Vacuoles, Centrioles



Animal cell does not have cell wall. The outermost layer is plasma membrane.

Plasma membrane:

It is ultra-thin, elastic, porous, semipermeable membrane.

It gives shape and provides mechanical support. It also checks the entry or exit of the substances.

Cytoplasm:

The space between plasma membrane and nucleus is filled with cytoplasm. Aqueous phase of cytoplasm excluding cell organelles is called Cytosol.

It is a colourless, homogenous, translucent, amorphous & colloidal fluid. It is composed of various molecules & organic compounds.

Different membrane bounded cell organelles are suspended in cytoplasmic matrix like- Endoplasmic reticulum, Golgi complex, Mitochondria, Ribosomes, Lysosomes, Vacuoles, Centrioles

Chloroplast is absent in animal cells

Nucleus:

Well developed, distinct nucleus with nucleolus covered with nuclear membrane is present.

Comparison between Animal cell and Plant cell

Characteristics	Animal Cell	Plant Cell
Cell Size	Small	Large
Cell Wall	Absent	Present, outside the Plasma membrane
Plasma Membrane	Outer membrane	Inner to the cell wall
Plastids	Absent	Present
Lysosomes	Distinct	Less frequent except in few members
Vacuoles	Absent, except a few	Present, many & distinct
Centriole & Centrosome	Present	Absent

Comparison between Prokaryotic cell and Eukaryotic cell

Characteristics	Prokaryotic Cell	Eukaryotic Cell
Cell Size	Small, 1-10 µm	Large, 10-100 µm
Cell Wall	Usually present; chemically complex	Present in plant cells and fungi, chemically simple in nature
Nucleus	Absent. Instead, they have a nucleoid	Present
Nuclear membrane	Absent	Present
Cytoplasm	No streaming movement	Exhibits streaming movement
Chromosomes	only one, contains DNA & no proteins	Mmore than one, contains DNA & proteins
DNA arrangement	Circular	Linear
Respiratory System	In plasma membrane (Mesosomes)	In mitochondria
Mitochondria	Absent	Present
E.R. & Golgi Complex	Absent	Present
Plasmids	Present	Very rarely found in eukaryotes
Ribosome	Small, 70S type	Large. 80S type
Lysosome	Lysosomes and centrosomes are absent	Lysosomes and centrosomes are present
Vacuoles	Absent	Present
Mitosis	does not occur	occurs
Exocytosis & Endocytosis	Absent	Present