MODULE 1

Aim

The aim of this module is to provide students with an introduction to cell biology.

Contents and Objective

On completion of this module, students will be able to:

- Describe cells
- State the major discoveries in cell biology
- Explain the Cell Theory
- List the basic properties of cells
- Classify cells into Prokaryotic and Eukaryotic and list their unique features
- Understand and explain the structures and functions of the prominent organelles of eukaryotic cells
- Differentiate between animal and plant cells

Introduction

The smallest structural and functional unit of an organism is called cell. All living things are made up of one or more cells. Cells are responsible for keeping us alive and functioning. They are too small to be seen or touched. The diversity of cells in terms of shape and size is enormous, yet all of them share some basic characteristics such as-

- Cytoplasm
- Cell membrane
- Genetic material (DNA)

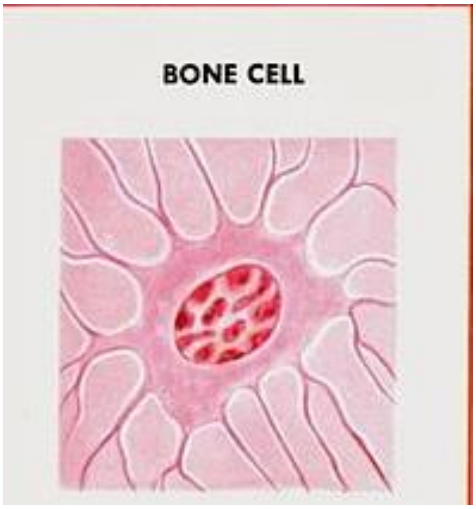
Cells are classified into two types based on their internal diversity:

- Prokaryotic Cells
- Eukaryotic Cells

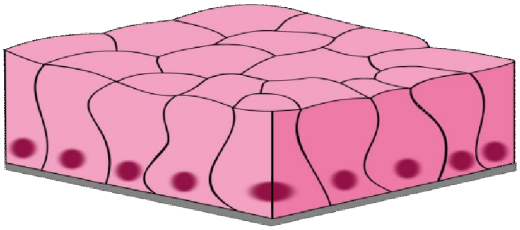
The prokaryotic cells are found in **Bacteria** and **Archaea** domains while the eukaryotic cells are found in the **Eukarya** domain.

Cell, whether prokaryotic or eukaryotic, perform a number of roles:

- **Bone Cells-** Bone cells, also known as **osteocytes**, are found in the bones. They provide strength to the body and support the frame-work of the body by enclosing the organs in a skeletal system.



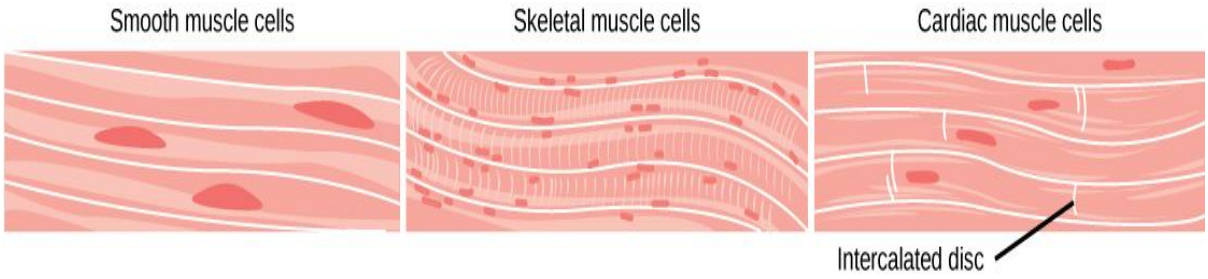
Epithelial Cells- They cover the layers of all the organs.



Simple Epithelial Cells

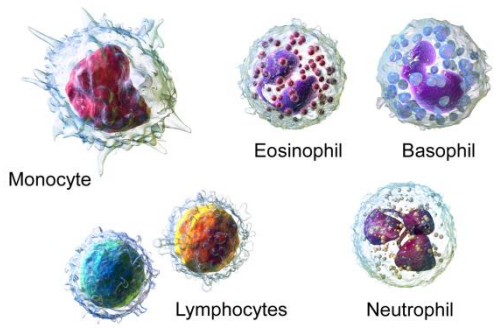
- **Muscle Cells-** They are also known as **myocytes**. They help in providing movement to the body. They are mainly of three types-

1. Cardiac Muscles Cells- These cells are found in the heart. Their function is to help in the contraction of heart and generate heartbeats.
2. Skeletal Muscle Cells- They are attached to long bones of limbs and help in their movement.
3. Smooth Muscle Cells- These are present in stomach, intestine, blood vessel walls. Their function is to help in food movement through the gut.



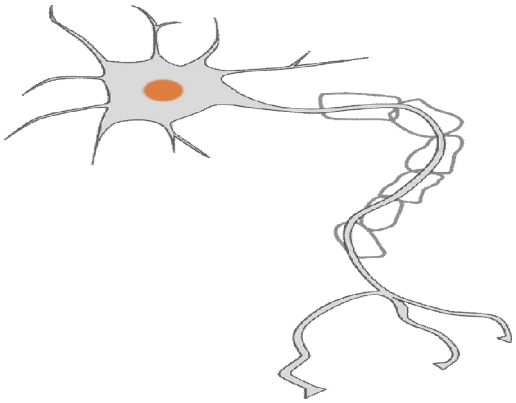
- **Blood Cells-** All the White Blood Cells (WBCs), Red Blood Cells (RBCs), and thrombocytes are listed under this category. These cells are unique in that they never multiply. Instead they are formed from other cells. They have a limited lifespan and generally die out after a certain period of time. These are mainly found in the bloodstream.

Red Blood Cells



White Blood Cells

- **Neurons-** Neurons are found in the brain and spinal cord. They form the nervous system. Neurons are the longest cells of the body. Their function is to transfer signals throughout the body.



Structure of a Neuron

DISCOVERY OF CELLS

As mentioned earlier, the cells are too small to be seen with naked eyes. They can only be observed with the help of a microscope. Thus, the discovery of cells was made possible after the invention of microscopes.

Cells were first observed by Robert Hooke in 1665 using a compound microscope. When he observed thin slices of cork, he saw a large number of tiny structures. He named these structures as cells. Robert Hookeôs observation was published in his book *Micrographia.*

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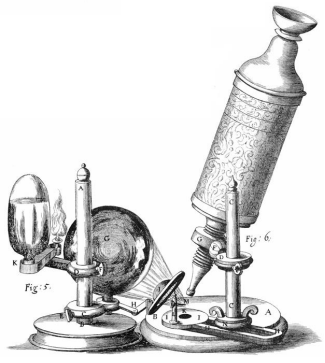


Robert Hooke's microscope

Robert Hooke

Anton Van Leeuwenhoek was another scientist who observed these cells after Robert Hooke but with improved lenses in his microscope. His microscope could magnify the objects better.

He observed moving objects under the microscope which he called ñanimalculesò. These included Protozoa and bacteria.

Formulation of Cell Theory

In 1830s, Theoder Schwann and Matthias Jakob Schleiden summarized their intensive observations made in a number of plants and animals respectively and came to the following conclusions about cells:

1. The cell is the unit of structure, physiology and organization.
2. Cells retain a dual existence as a distinct entity and a building block in construction of organisms.
3. Cells are formed spontaneously.

Later Rudolf Virchow (1855) modified the Cell Theory by adding another point which states that **all cells come from pre-existing cells.**

Thus, the modern cell theory was formed and has the following points listed under it:

1. All living organisms are composed of one or more cells.
2. All new cells arise from pre-existing cells.
3. The cell is the basic unit of life.

BASIC PROPERTIES OF CELLS

- Cells are highly organized and complex.
- Cells possess a genetic program and the means to use it.
- Cells are capable of producing more of themselves by mitosis and meiosis.
- They can carry out a variety of chemical reactions.
- Cells can acquire and utilize energy in the form of ATP.
- Cells engage in mechanical activities.
- Cells are able to respond to stimuli by the help of receptors which are present on their surface.

CLASSIFICATION OF CELLS

Cellular organization is found in all the living organisms (bacteria, fungi, algae, plants and animals). Organisms are either unicellular or multicellular.

Unicellular organsisms are those which have only cell in their body. Examples include bacteria, protozoa and some algae.

Multicellular organisms are the ones which have many cells in their body. Eg- Fungi, plants and animals.

Living organisms include one of the following ï

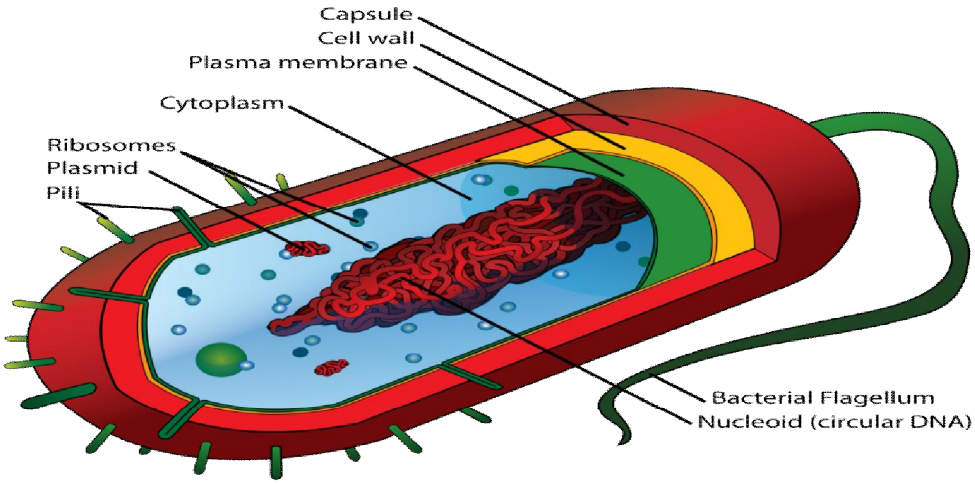
- Prokaryotic cells
- Eukaryotic cells

This classification of cells is based on the complexity of the cells.

Eukaryotes are further classified into plant cells and animal cells based on certain differences. This will be dealt with in upcoming sections.

Prokaryotic Cells

ðProômeans before and ðkaryoticômeans nucleus. Thus, prokaryotic cells are those which lack true nucleus. They also do not have membrane-bound organelles.



A Typical Prokaryotic Cell

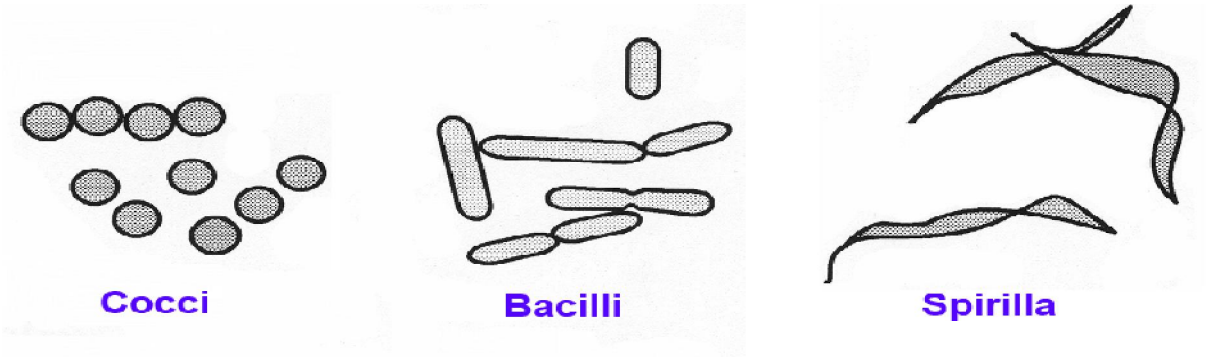
Prokaryotic cells consist of the following structures-

1. **Cell membrane**
    - It surrounds the cytoplasm of the cell and separates the cellôs interior environment from the outer environment and also regulate the flow of material in and out of the cell.
2. **Cytoplasm**
    - The substance in a cell between the nucleus and cell membrane is called cytoplasm.
    - Composition of cytoplasm is jelly-like and is composed of mainly water (70-90%) and is colourless.
    - The cytoplasm makes up most of the content of a cell.
    - It also has streaming property.
    - Most of the cellular activities occur within the cytoplasm. For eg., glycolysis, cell division.
    - All the cell organelles are found to be suspended in the cytoplasm.
3. **Nucleoid**
    - Nucleoid is a coiled structure present in a bacterial cell which contains DNA.
4. **Flagella**
    - A flagellum is a slender, whip-like protrusion on the body or prokaryotic cells.
    - Their main function is the movement and locomotion of the cell.
    - In some cases, flagella also possess sensory functions.
5. **Capsule**
    - A capsule is an additional covering found in some bacterial cells.
    - It protects the cell from getting phagocytosed by other cells or getting attacked by viruses.
6. **Cell wall**
    - Cell wall is the outermost layer of bacterial cells.
    - It provides strength and shape to the cell.
    - All the bacterial cells have a cell wall. One exception is Mycoplama.

Morphology of prokaryotic cells

Prokaryotic cells vary greatly in their cells. The most common of these are ï

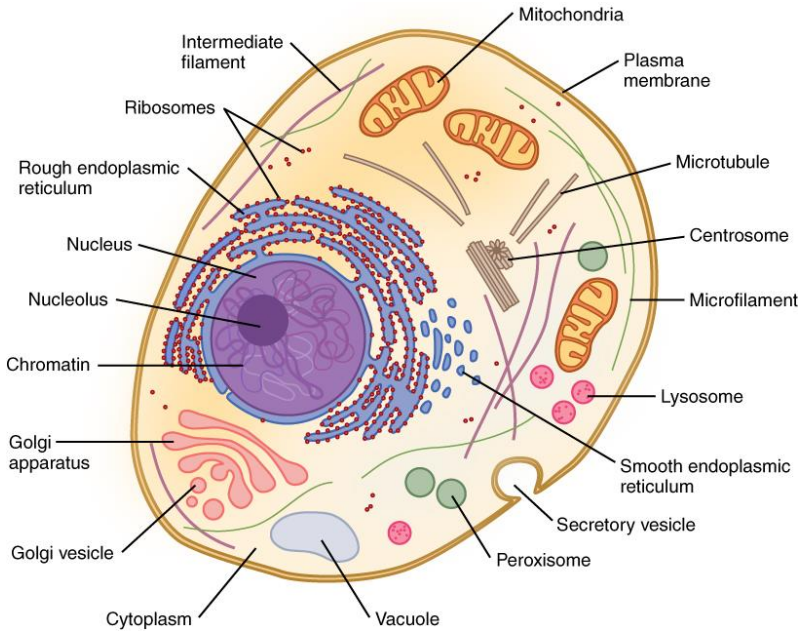
- Cocci ï spherical.
- Bacilli ï rod-shaped.
- Spirochaete ï spiral-shaped.
- Vibrio ï comma-shaped.



Morphology of prokaryotic cells

Eukaryotic Cells

A eukaryotic cell has a true nucleus with a nuclear membrane and nucleolus. They also contain all the membrane-bound organelles. The structure and functions of individual organelles will be discussed in the later sections.



A Typical Eukaryotic Cell

Table: A comparative account of the features of photosynthetic and eukaryotic cells

Feature	Prokaryotic cell	Eukaryotic cell
Size of the cell	1-4 ε m or less in diameter	Greater than 5 ε m in diameter
Cell type	Mostly unicellular. However, some Cynobacteria may be multicellular	Multicellular
Nucleus	True nucleus is absent	True nucleus along with nuclear membrane and nucleolus are present
Chromosome	Single circular, without histones	Multiple, linear, with histones
Genes	Expressed in groups called operons	Expressed individually
Cell Division	Binary fission or budding	Involves mitosis (or meiosis)
Sexual reproduction	No meiosis. Only transfer of DNA occurs	Involves meiosis
Permeability of nuclear membrane	Absent	Present
Cytoskeleton	Absent	Present
Membrane-bound Organelles	Absent	Present
Plasma Membrane	Contains part of respiration and in some photosynthetic machinery	Does not carry out respiration or photosynthesis

Where did the Eukaryotic cells come from?

Endosymbiotic Theory of Evolution of Eukaryotic Cells

Scientists believe that 4 billion years ago the primitive cells had the following modes nutrition:

- Invagination of food particles
- Photosynthesis
- Absorb free-floating particle in their surrounding

The theory states that a free-living bacterium was engulfed by another cell as a food particle. This engulfed cell ended up staying inside and formed a distinct compartment inside the host cell.

The host cell became dependent on the engulfed cells for energy because it was an aerobic cell and gradually evolved into the powerhouse of the cell. Today we know it as mitochondria.

The process of one organism taking up permanent residence inside another and eventually evolving into a single lineage is known as endosymbiosis.