Lecture 2

Cell Biology I

By

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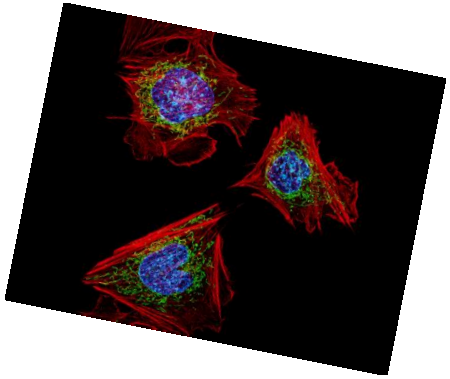
What is Cell Biology in Biochemistry?

Cell biology aims to understand the structure and physiological function of individual cells, how they interact with their environment, and how large numbers of cells coordinate with each other to form tissues an organisms. As such, cell biology is at the heart of all biological sciences and key to understanding the development and progression of human diseases.

WHAT ARE CELLS?



Cells provide structure and function for all living things, from microorganisms to humans. Scientists consider them the smallest form of life. Cells house the biological machinery that makes the proteins, chemicals, and signals responsible for everything that happens inside our bodies.

What do cells look like?

Cells come in different shapes—round, flat, long, star-like, cubed, and even shapeless. Most cells are colorless and see-through. The size of a cell also varies. Some of the smallest are one-celled bacteria, which are too small to see with the naked eye, at 1-millionth of a meter (micrometer) across. Plants have some of the largest cells, 10–100 micrometers across. The human cell with the biggest diameter is the egg. It is about the same diameter as a hair strand (80 micrometers).

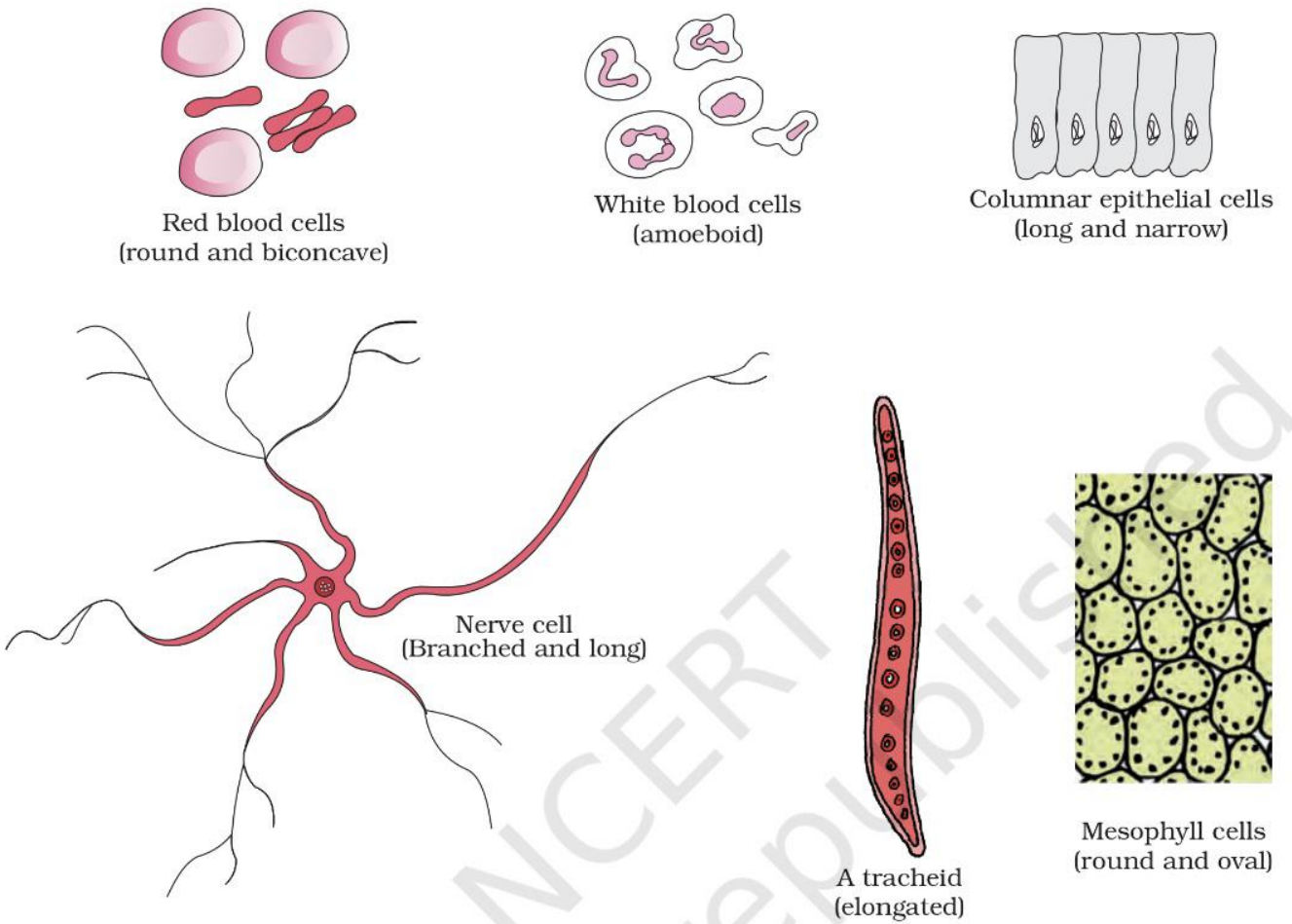
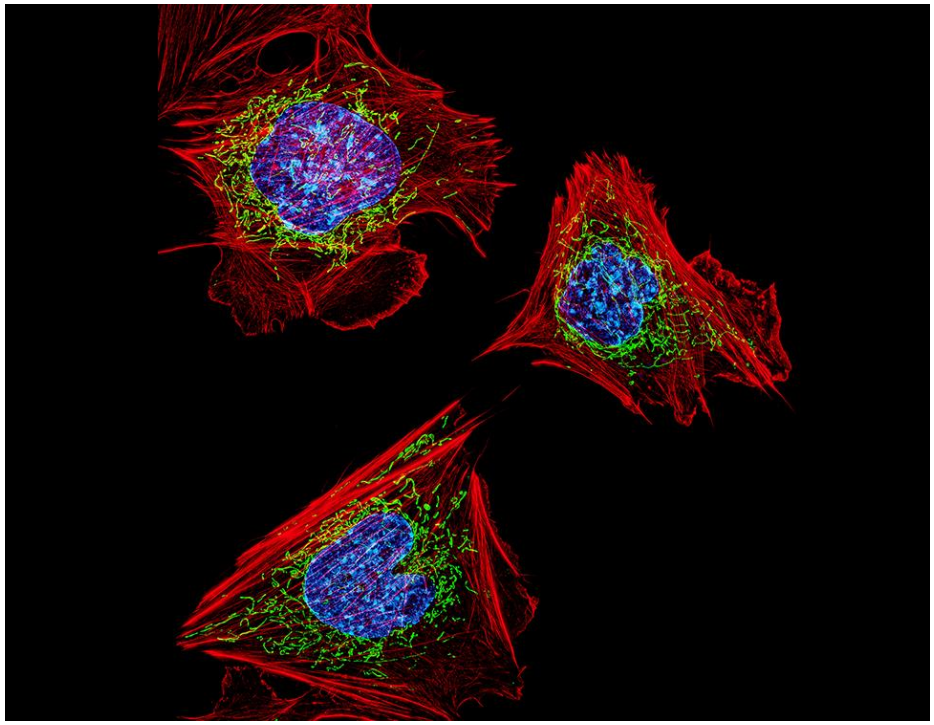
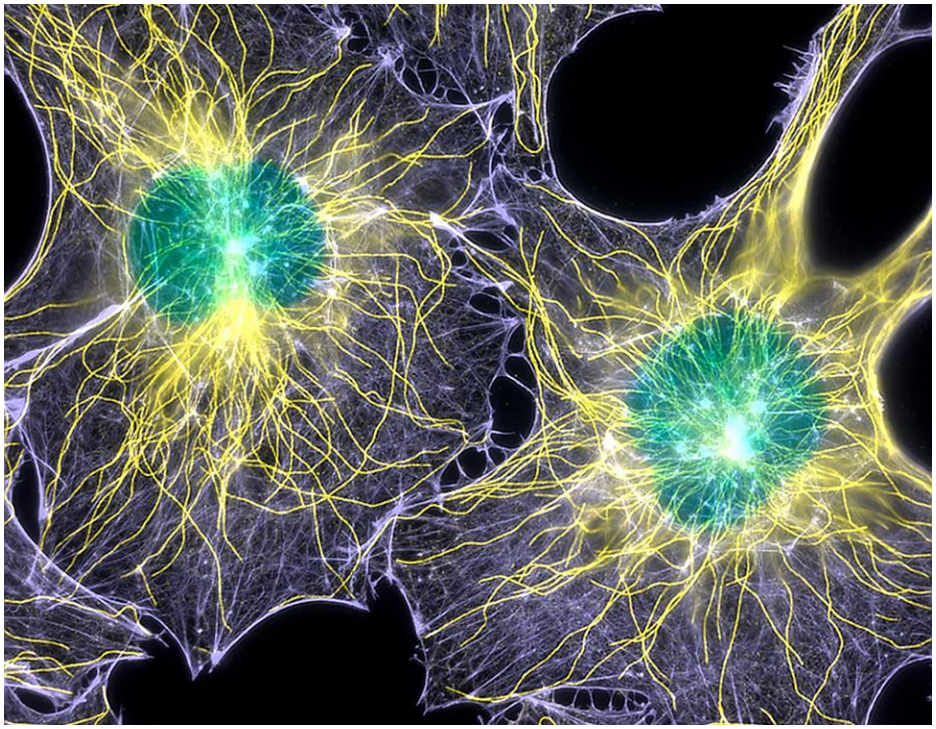


Diagram showing different shapes of the cells



Fibroblast cells with nuclei (blue, circular, center), energy factories (green, surrounding the nucleus), and the actin cytoskeleton (red, outermost). Credit: Dylan Burnette and Jennifer Lippincott-Schwartz, *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, National Institutes of Health.



Researchers used fluorescent tags to illuminate the intricate network of microtubule (yellow, center filaments) and actin filament (purple, outermost) fibers that build a cell's structure. Credit: Torsten Wittmann, Scripps Research Institute

How many different types of human cells are there?

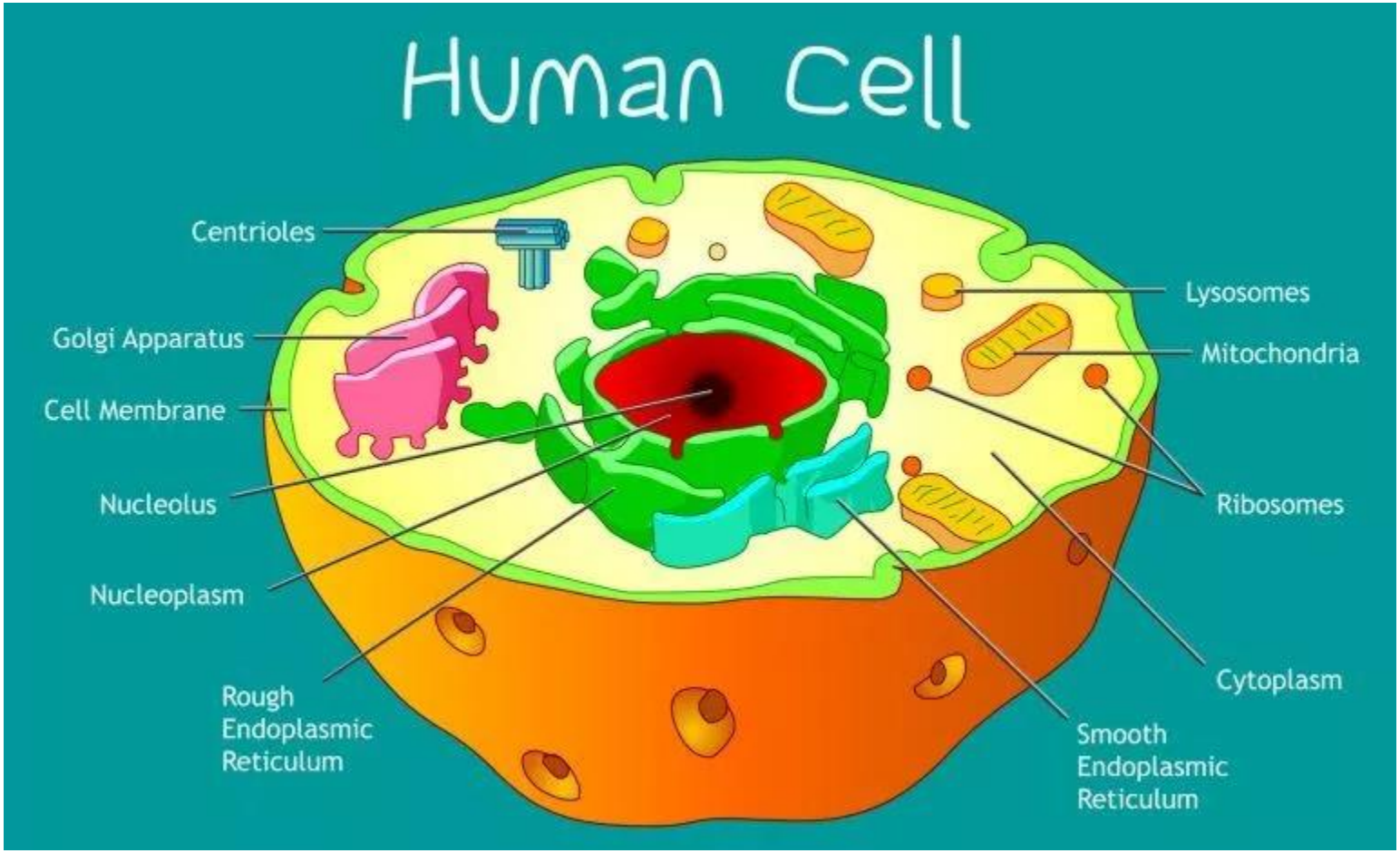
The trillions of cells that make up a human are organized into about 200 major types. All of a person's cells contain the same set of genes. However, each cell type "switches on" a different pattern of genes, and this determines which proteins the cell produces. The unique set of proteins in different cell types allows them to perform specialized tasks. For instance, red blood cells carry oxygen throughout the body. White blood cells kill germ invaders. Intestinal cells release molecules that help digest food. Nerve cells send chemical and electrical messages that produce thoughts and movement. And heart cells contract in unison to pump blood.

What are eukaryotic and prokaryotic cells, and how are they different?

When putting cells into categories, scientists can tell eukaryotic cells apart from prokaryotic cells because they look different. Eukaryotic cells make up animals, plants, fungi, and some single-celled organisms. And they have a number of structures inside them, called organelles. The most prominent organelle is the nucleus, which contains the cell's genetic material, or DNA. Prokaryotic cells don't have a nucleus or other organelles. They are single-celled microorganisms that tend to be smaller than eukaryotic cells. There are two types of prokaryotic cells—bacteria and archaea.

What are some of the major organelles in a human cell?

- In addition to the nucleus, the most prominent organelles include the following:
- Mitochondria, the cell's power plants, convert energy from food into the body's main energy source, adenosine triphosphate (ATP).
- Ribosomes are molecular factories that make proteins.
- The endoplasmic reticulum (ER), a network of interconnected sacs, processes newly made secreted and membrane proteins and produces fatty substances called lipids.
- The Golgi complex receives proteins and lipids from the ER, packages them, and sends them to their final destinations inside the cell, within the cell membrane, or outside the cell.
- Lysosomes, the cell's garbage dumps, break down waste materials and dispose of them or recycle them.


Human Cell
Centrioles
Golgi Apparatus
Cell Membrane
Nucleolus
Nucleoplasm
Rough Endoplasmic Reticulum
Lysosomes
Mitochondria
Ribosomes
Cytoplasm
Smooth Endoplasmic Reticulum

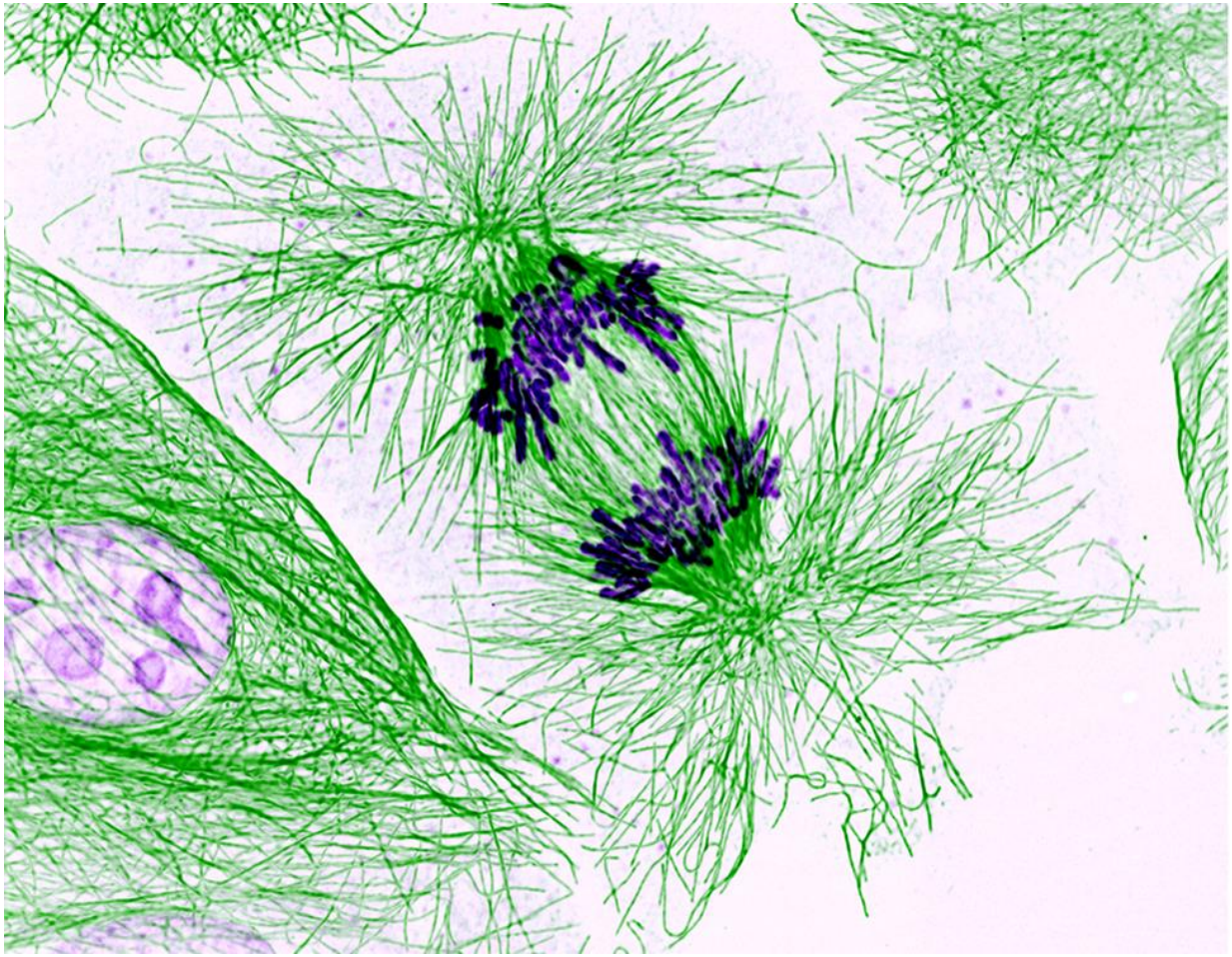
How do cells move?

Many types of cells can move. Single-celled organisms move to find food. And even cells inside multicellular organisms may need to get around. For example, immune system cells must move toward invaders. And sperm needs to “swim” to fertilize eggs.

Cells move in several ways. Some simply float through water or other liquids. Some push themselves along using long, thin proteins, called flagella, and cilia that stick outside the cell membrane and wave around. Some “crawl” along, using what’s called amoeboid movements, in which cytoplasm-filled protrusions scoot the cell forward.

Within cells, nutrients and organelles move around to carry out various cellular functions. This kind of internal movement is called cyclosis, or cytoplasmic streaming. The internal structure of cells, which is called the cytoplasm, creates a directional flow that pushes the contents of the cells around.

Scientists study cell movement to better understand how cells work, including how cancer cells move from one tissue to another and how white blood cells move to heal wounds and attack invaders.



This is a pig cell in the process of dividing. The image shows the chromosomes (purple, shorter, center) and the cell skeleton (green, fibrous, outer). Credit: Nasser Rusan, National Heart, Lung, and Blood Institute, National Institutes of Health.

Cell: structural unit of life

When you look around, you see both living and non-living things. You must have wondered and asked yourself – 'what is it that makes an organism living, or what is it that an inanimate thing does not have which a living thing has' ? The answer to this is the presence of the basic unit of life – the **cell in all living organisms.** All organisms are composed of cells. Some are composed of a **single**

cell and are called **unicellular organisms** while others, like us, composed of **many cells**, are called **multicellular organisms**.

WHAT IS A CELL?

Unicellular organisms are capable of :

(i) independent existence and

(ii) (ii) performing the essential functions of life.

Anything less than a complete structure of a cell does not ensure independent living. Hence, cell is the fundamental structural and functional unit of all living organisms.

Anton Von Leeuwenhoek first saw and described a live cell. Robert Brown later discovered the nucleus. The invention of the microscope and its improvement leading to the electron microscope revealed all the structural details of the cell.

Overview of Cell

You have earlier observed cells in an onion peel and/or human cheek cells under the microscope. Let us recollect their structure. The onion cell which is a typical plant cell, has a distinct **cell wall** as its outer boundary and just within it is the **cell membrane**. The cells of the human cheek have an **outer membrane as the delimiting structure of the cell. Inside each cell is a dense membrane bound structure called nucleus.** This nucleus contains the chromosomes which in turn contain the genetic material, DNA. Cells that have membrane bound nuclei are called eukaryotic whereas cells that lack a membrane bound nucleus are prokaryotic. In both prokaryotic and eukaryotic cells, a semi-fluid matrix called cytoplasm occupies the volume of the cell. The cytoplasm is the main arena of cellular activities in both the plant and animal cells. Various chemical reactions occur in it to keep the cell in the ‘living state’.

Besides the nucleus, the eukaryotic cells have other membrane bound distinct structures called organelles like the **endoplasmic reticulum (ER),the golgi complex, lysosomes, mitochondria, microbodies and vacuoles.**

The prokaryotic cells lack such membrane bound organelles.

Ribosomes are non-membrane bound organelles found in all cells – both eukaryotic as well as prokaryotic. Within the cell, ribosomes are found not only in the cytoplasm but also within the two organelles – chloroplasts (in plants) and mitochondria and on rough ER.

Animal cells contain another non-membrane bound organelle called centrosome which helps in cell division.

Cells differ greatly in size, shape and activities (Figure below). For example,Mycoplasmas, the smallest cells, are only 0.3 µm in length while bacteria could be 3 to 5 µm. The largest isolated single cell is the egg of an ostrich.Among multicellular organisms, human red blood cells are about 7.0 µm in diameter. Nerve cells are some of the longest cells. Cells also vary greatly in their shape. They may be disc-like, polygonal, columnar, cuboid ,threat like, or even irregular. The shape of the cell may vary with the function they perform.

PROKARYOTIC CELLS

Prokaryotic cells are the most primitive cells and have simple structural organization. It has a single membrane system. They include bacteria, viruses, blue-green algae, mycoplasmas, rickettsias, spirochetes etc. Cyanobacteria or blue green algae are the largest and most complex prokaryote, in which photosynthesis of higher plants type have evolved. Prokaryotes are included in the kingdom Monera and the super kingdom Prokaryota. The Prokaryotes have the following characters:

1. The size of prokaryotic cells ranges between 1 to 10 µm. They occur in a variety of forms.
2. Prokaryotic cell consists of three main components:

(I) Outer covering: It is composed of inner cell or plasma membrane, middle cell wall and outer slimy capsule.

a. Cell membrane: Cell membrane made up of lipids and proteins, is thin and

flexible and controls the movement of molecules across the cell. Respiratory enzymes

are carried by it for energy releasing reactions. Mesosomes, the in-folds of plasma

membrane bears respiratory enzymes and these are considered analogous to mitochondria of eukaryotic cells. Similarly, the pigments and enzymes molecules that absorb and convert the light into chemical energy in photosynthetic cells are also associated with the plasma membrane's in-folds called photosynthetic lamella.

These lamellae are analogous to the chloroplast of eukaryotic cells. Plasma membrane plays role in replication and division of nuclear material. Since the in-folds remain continuous with the cell membrane, they are not considered as separate compartments. Thus, prokaryotic cell is non-compartmentalized.

b. Cell wall : It is a rigid or semi-rigid non-living structure that surrounds the cell membrane and its thickness ranges between 1.5 to 100 µm. Chemically it is composed of peptidoglycans. . Some bacteria such as mycoplasmas lack cell wall.

c. Slimy capsule: A gelatinous coat outside the cell wall is the slimy capsule. It is composed of largely of polysaccharides and sometimes it may have polypeptides and other compounds also. It protects the cell against desiccation, virus attacks, phagocytosis and antibiotics

(II) Cytoplasm: Prokaryotic cytoplasm contains proteins, lipids, glycogen and inorganic ions along with enzymes for biosynthetic reactions and ribosomes, tRNA and mRNA for protein synthesis.

(III) Nucleoid: Nuclear envelope is absent in prokaryotic cell and the genetic materia lies directly into the cytoplasm. Such nuclear material is known as nucleoid.

3. Plasmids: In some prokaryotic cells, in addition to nucleoid, a small circular double stranded DNA molecule is present. It is called plasmid. Plasmids have 1000 to 30,000 base pairs and they generally encode proteins required by the organism to resist antibiotic and other toxic material.

4. Flagellum: It is a whip like locomotory structure found in many bacteria. It is 150Å thick and 10 to 15µm long. As the flagellum does not have any surrounding membrane, it grows at the tip.