



CELL BIOLOGY, GENETICS, BIOSTATISTICS AND ECOLOGY (PAPER CODE: BOT 551)



By
Dr. Kirtika Padalia
Department of Botany
Uttarakhand Open University, Haldwani
E-mail: kpadalia@uou.ac.in

OBJECTIVES

The main objective of the present lecture is to cover the topic and make it easy to understand and interesting for our students/learners.

BLOCK – I : CELL BIOLOGY

Unit –2 : Ultrastructure and function of plant cell and organelles

CONTENT

- ❑ Introduction
- ❑ Properties of cell
- ❑ Nature and functions of cell
- ❑ Type of cells
 - Prokaryotic cell
 - Eukaryotic cell
- ❑ Structure of the plant cell
- ❑ Key points
- ❑ Terminology
- ❑ Assessment Questions
- ❑ Bibliography

WHAT IS CELL ???

- ❖ A cell is the smallest unit of life.

Or

- ❖ Cells are the basic building blocks of all living things.

Or

- ❖ The cell is the basic structural, functional, and biological unit of all known organisms.

Or

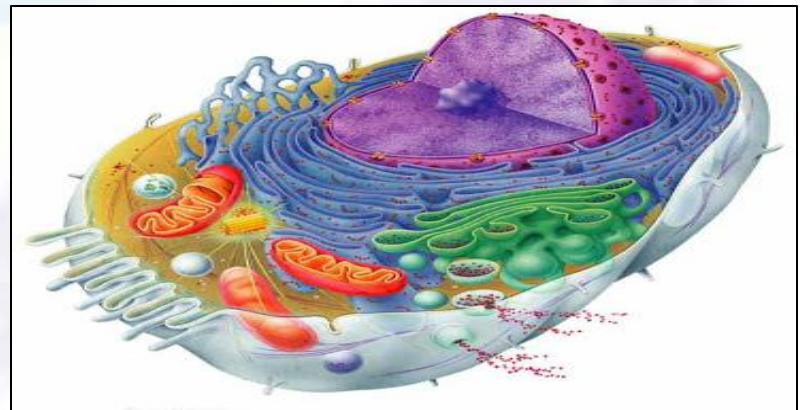
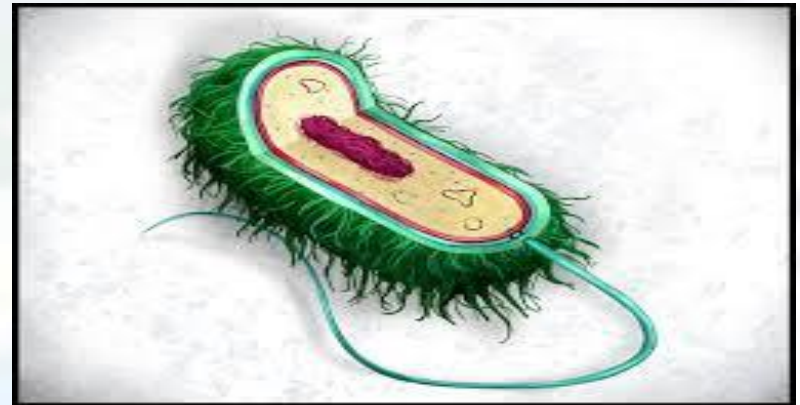
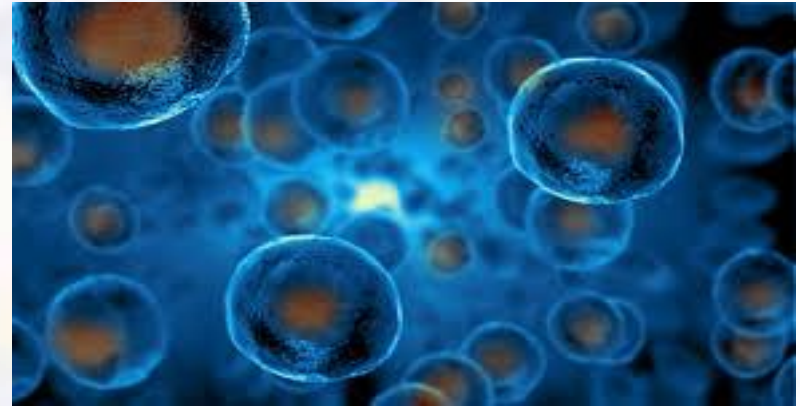
- ❖ Cell is the basic membrane-bound unit that contains the fundamental molecules of life and of which all living things are composed.

Or

- ❖ The smallest structural and functional unit of an organism, which is typically microscopic and consists of cytoplasm and a nucleus enclosed in a membrane.

Or

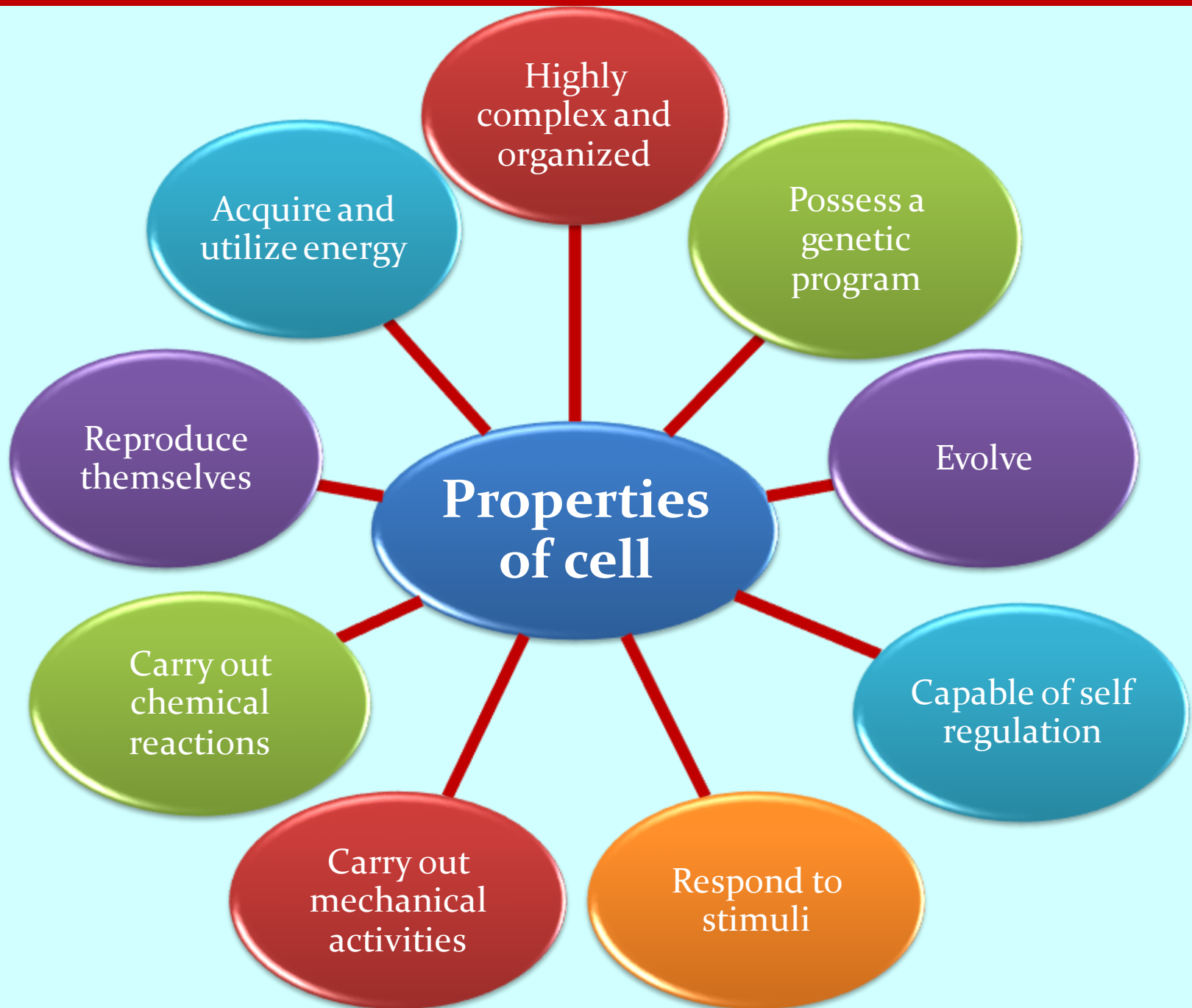
- ❖ The cell is a unit of biological activity delimited by a semipermeable membrane and capable of self-reproduction in a medium free of other living systems.



INTRODUCTION

- ❖ Cells emerged on the Earth at least 3.5 billion years ago.
- ❖ The word cell is derived from Latin word “cella” meaning “small room”.
- ❖ The study of cells is called cell biology, cellular biology, or cytology.
- ❖ Cells were discovered by Robert Hooke in 1665.
- ❖ Although cells are much larger than atoms, they are still very small.
- ❖ Cell theory, first developed in 1839 by Matthias Jakob Schleiden and Theodor Schwann.
- ❖ The cell theory states that all organisms are composed of one or more cells. That cells are the fundamental unit of structure and function in all living organisms, and that all cells come from pre-existing cells.
- ❖ Collectively, all the living cells are broadly classified into two category i.e., prokaryotic cells and eukaryotic cells, according to whether their genetic materials are enclosed by a nucleus envelope or not.
- ❖ Eukaryotic cells possess this envelope while a prokaryotic cell does not.
- ❖ Eukaryotic cells may have evolved from prokaryotic cells but contain different types of organelles like well-organized nucleus, endoplasmic reticulum, golgi body, mitochondria etc, which are specific in their functions.
- ❖ Eukaryotic cells are higher in biomass than the prokaryotic once.
- ❖ Single cell is often a complete organism in itself, such as a bacterium or yeast.

- ❖ All the living organisms except virus and certain group of plants (*Rhizopus*, *Vaucheria* etc) has well organized cellular body which may contain one or more cells.
- ❖ According to the number of cells, the organisms can divided into two category i.e., unicellular and multicellular
- ❖ The living organisms which made up of a single cell are known as unicellular organisms. E.g., All blue green algae, some higher algae (Diatoms, *Cosmarium*, *Chlorella*, *Microcystis*, *Pinnularia*, *Haematococcus* etc) and group of protozoa.
- ❖ The organism made up of more than one cell is called multicellular. Eg., most plants and animals.
- ❖ The cells are found in different varieties of shapes, sizes and numbers which indicate their evolutionary adaptation trends for different environmental conditions.
- ❖ Cells range in size from the smallest bacteria, only a few tenths of μm in diameter to certain large marine algae and to various bird eggs with dimension of centimeters.
- ❖ Cells have the ability to continue living in the absence of any other cell.
- ❖ However, this definition does not suitable for the viruses because they are capable to self-reproduce without have a finite semi-permeable membrane and only within the living cells.
- ❖ Cells consist of cytoplasm enclosed within a membrane, which contains many biomolecules such as proteins and nucleic acids.
- ❖ Most plant and animal cells are only visible under a microscope, with dimensions between 1 and 100 micrometres (Neil, 2006).
- ❖ The number of cells varies from species to species, it has been estimated that humans contain somewhere around 40 trillion (4×10^{13}) cells (Bianconi et al., 2013).

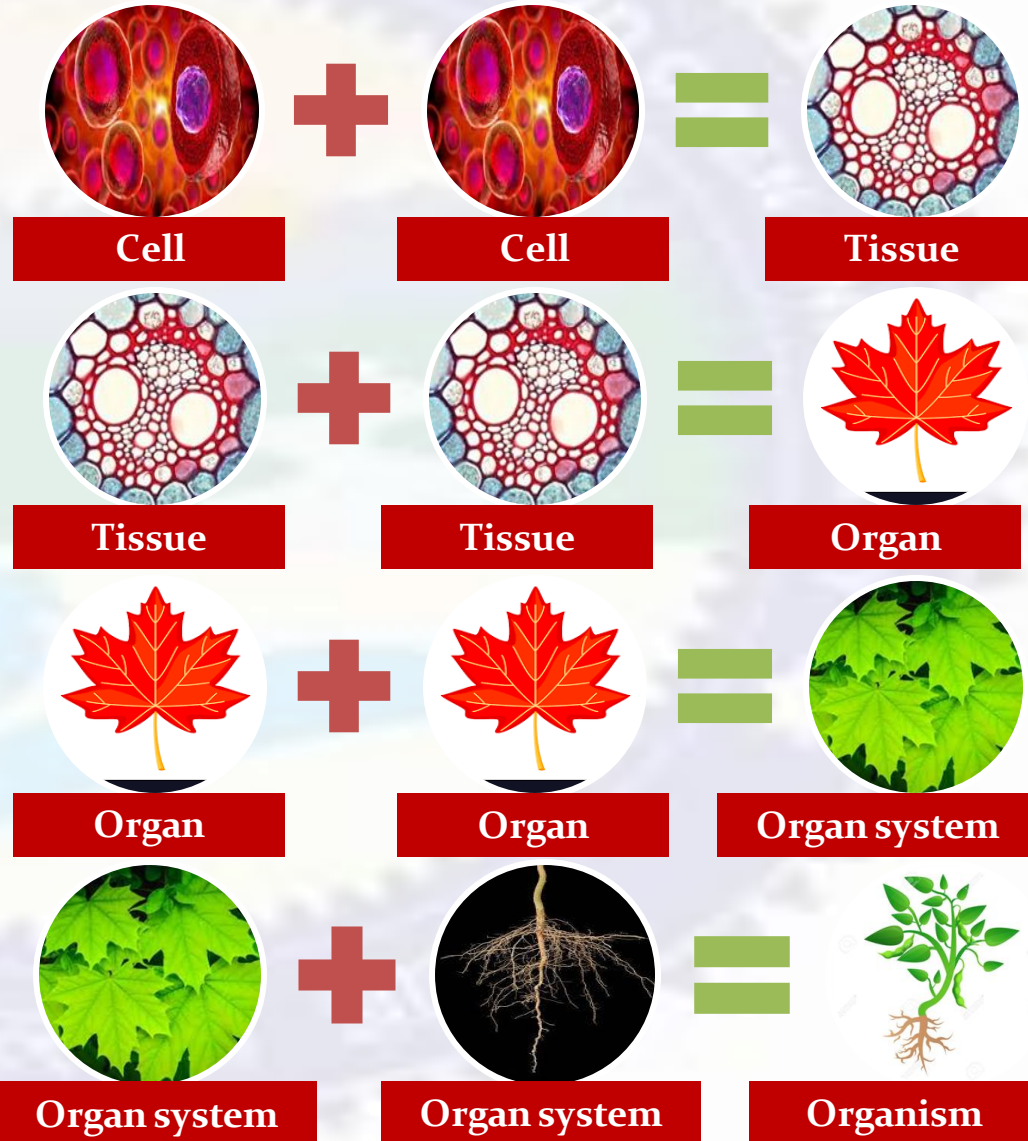


PROPERTIES OF CELL

- ❖ Life, in fact, is the most basic property of cells, and cells are the smallest units to exhibit this property. Few of their most fundamental properties of the cell are:

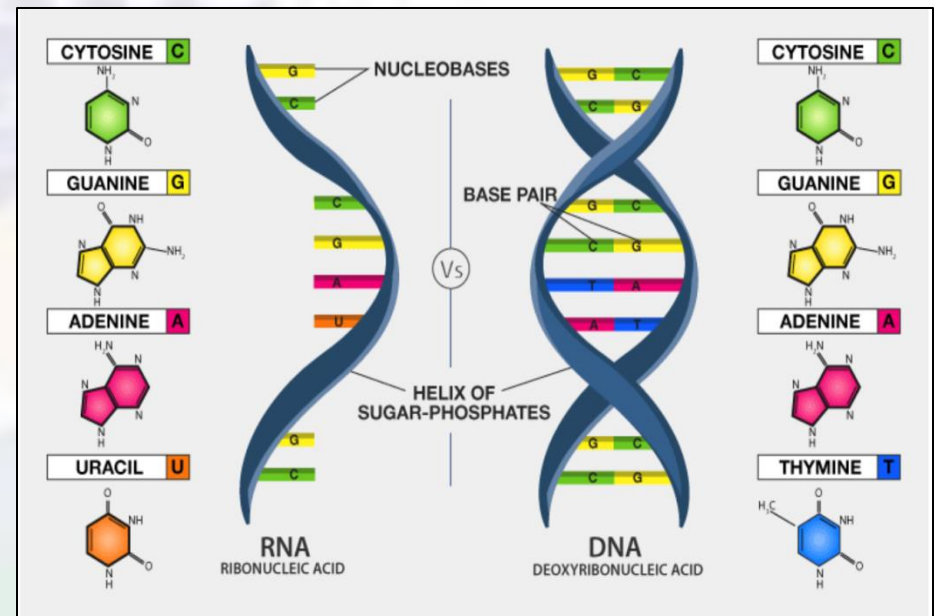
- ❑ **Cells are highly complex and organized**

- Cells of organisms are highly organized.
- Organisms are coordinated structures that consist of one or more cells.
- Even very simple, single-celled organisms are remarkably complex: inside each cell, atoms make up molecules.
- These organization of cell make up cell organelles and other cellular inclusions.
- In multicellular organisms, similar cells form tissues. Tissues, in turn, collaborate to create organs. Organs work together to form organ systems.

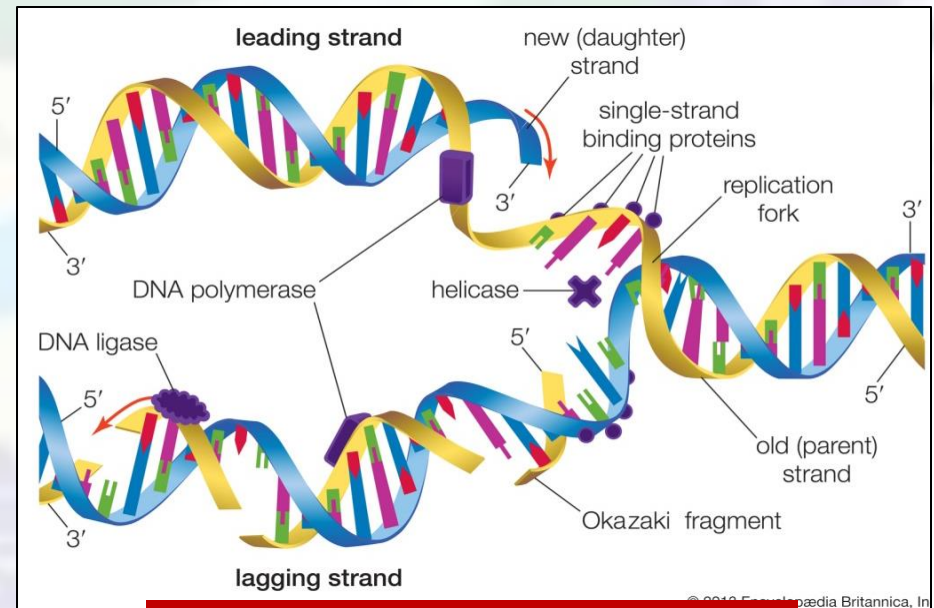


❑ Cells possess a genetic program

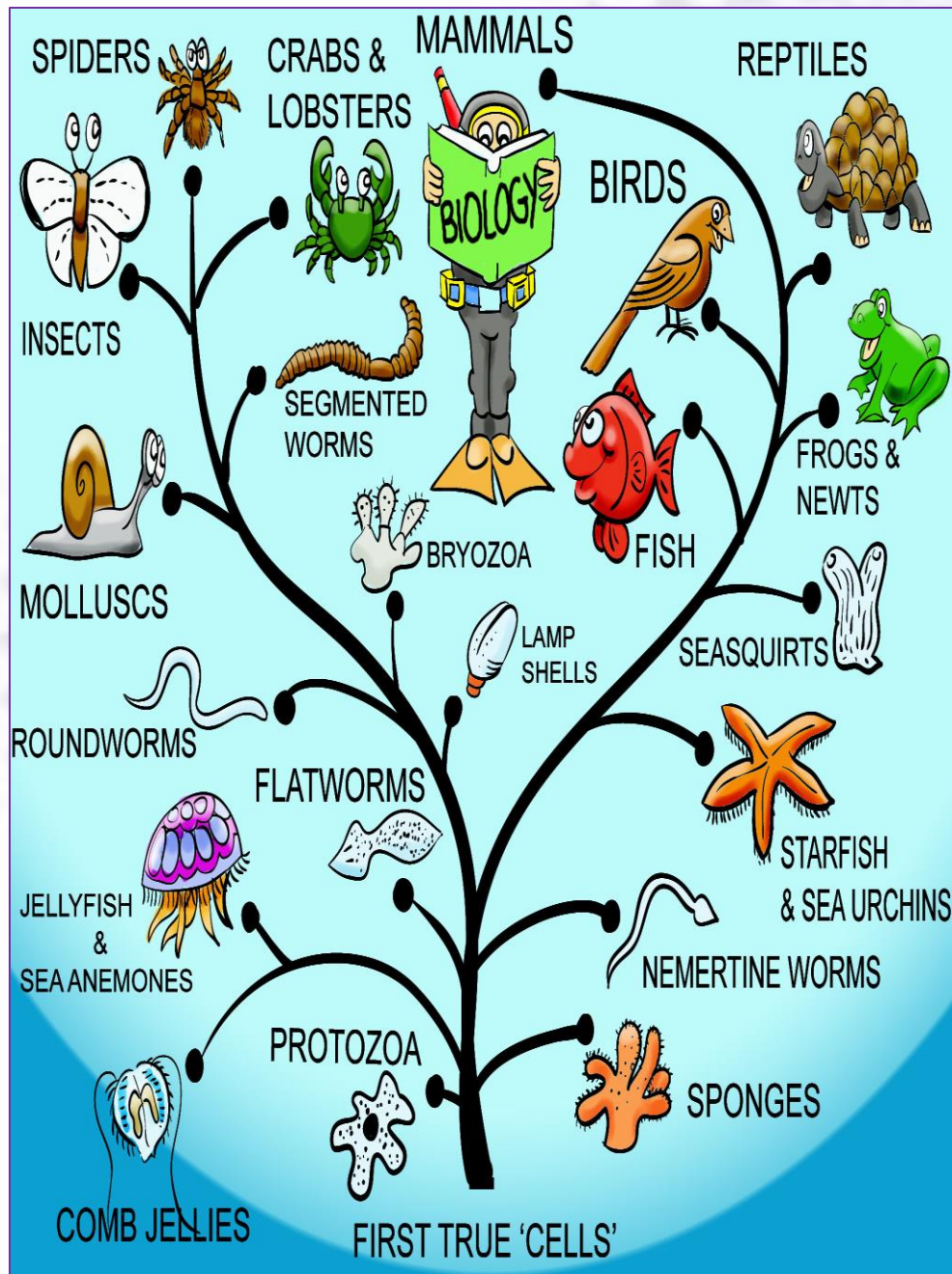
- All the living cells possess the genetic material which carry their genetic information from one generation to the next.
- Single-celled organisms reproduce by first duplicating their DNA.
- They then divide it equally as the cell prepares to divide to form two new cells.
- Multicellular organisms often produce specialized reproductive germline cells that will form new individuals.
- When reproduction occurs, genes containing DNA are passed along to an organism's offspring.
- These genes ensure that the offspring will belong to the same species and will have similar characteristics, such as size and shape.



Genetic material of the organisms



DNA replication program in cell

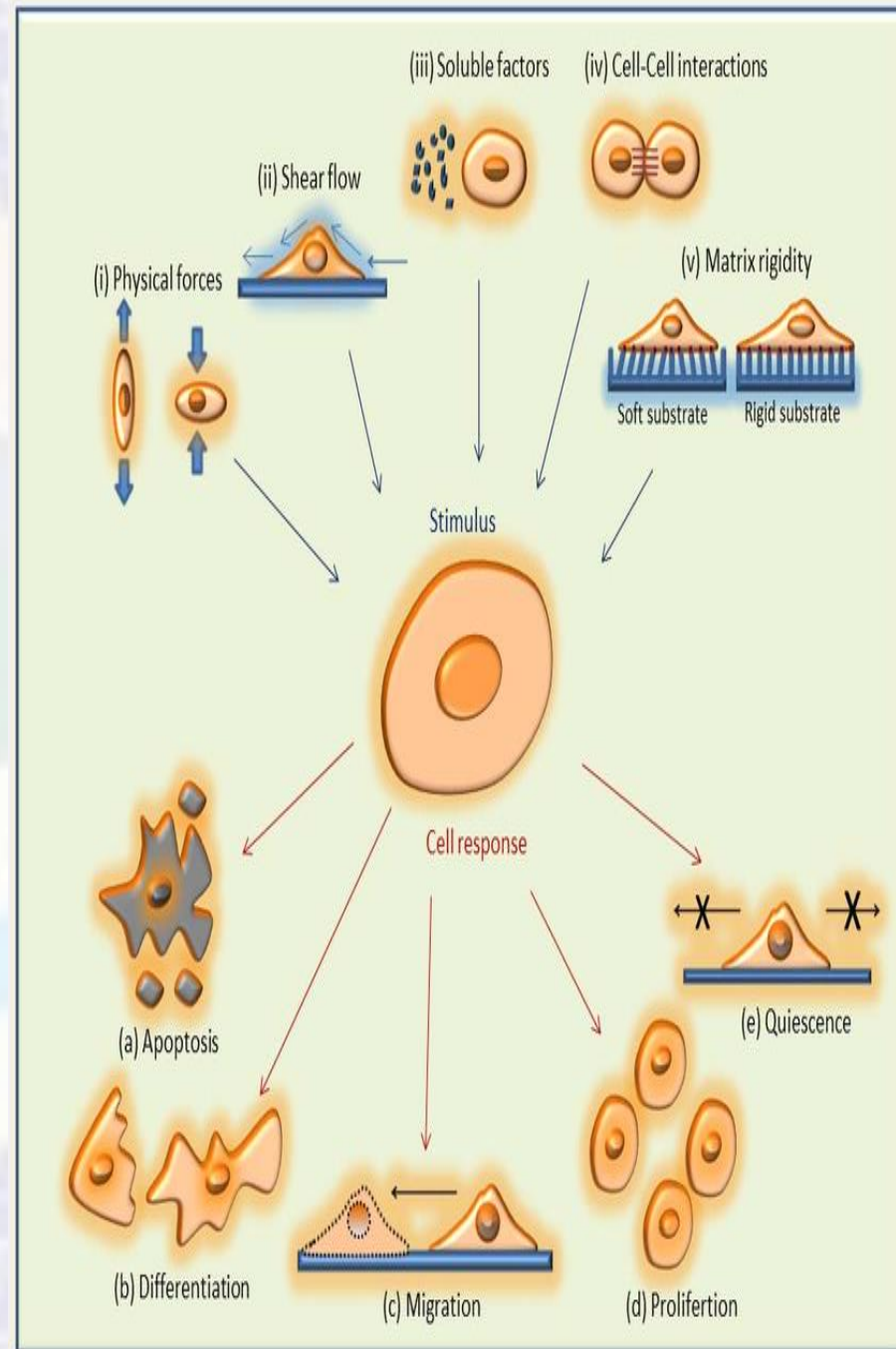


❑ Cells are evolve

- Cells continue to evolved from the simplest form of life to the most complex.
- As a population of organisms interacts with the environment, individuals with traits that contribute to reproduction and survival in that particular environment will leave more offspring.
- Over time those advantageous traits (called adaptations) will become more common in the population.
- Evolution is not simply an event of the past, but an ongoing process that continues to modify the properties of cells that will be present in organisms that have yet to appear.
- This process, change over time, is called evolution, and it is one of the processes that explain the diverse species seen in biology.

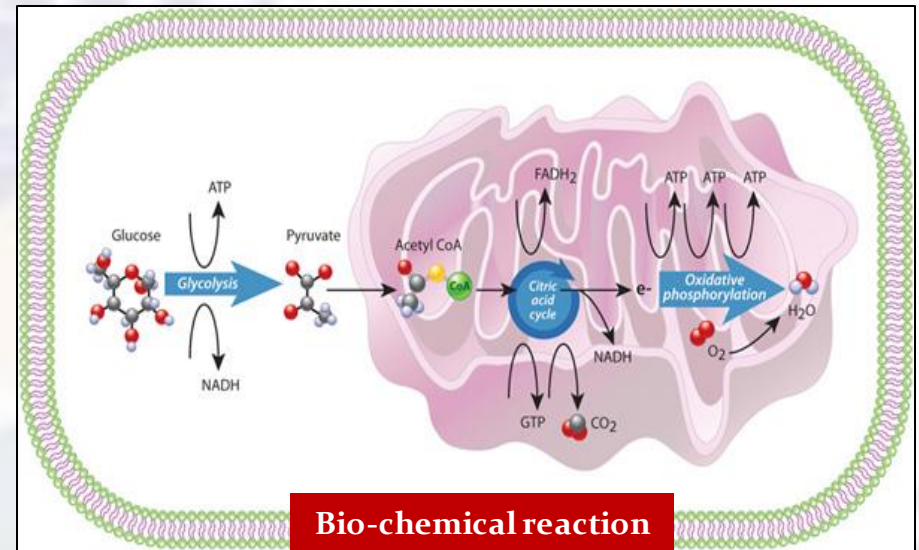
❑ Cells respond to stimuli

- Some cells respond to stimuli in obvious ways; a single-celled protist, for example, moves away from an object in its path or moves toward a source of nutrients.
- Cells within a multicellular plant or animal respond to stimuli less obviously.
- Most cells are covered with *receptors that interact with substances in the environment* in highly specific ways.
- Cells possess receptors to hormones, growth factors, and extracellular materials, as well as to substances on the surfaces of other cells.
- A cell's receptors provide pathways through which external stimuli can evoke specific responses in target cells.
- Cells may respond to specific stimuli by altering their metabolic activities, moving from one place to another, or even committing suicide.



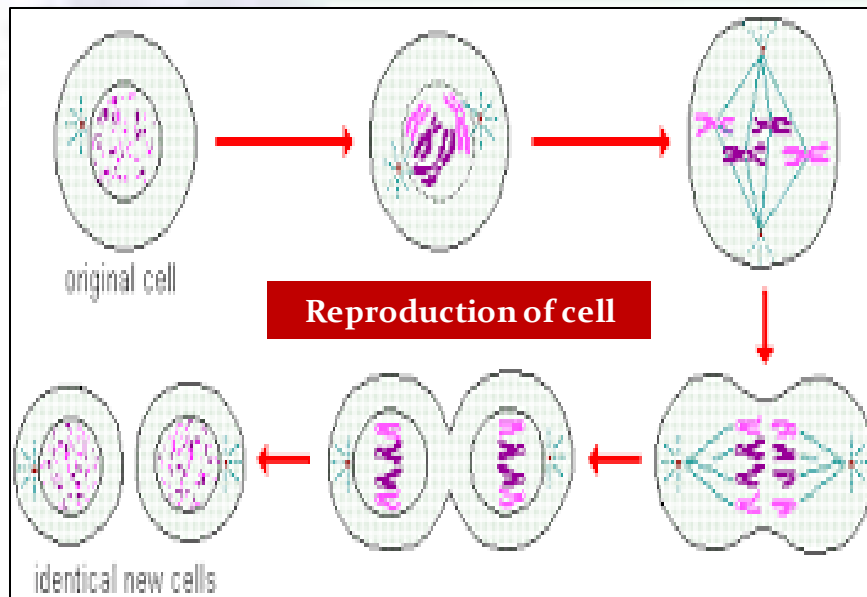
❑ Cells carry out chemical reactions

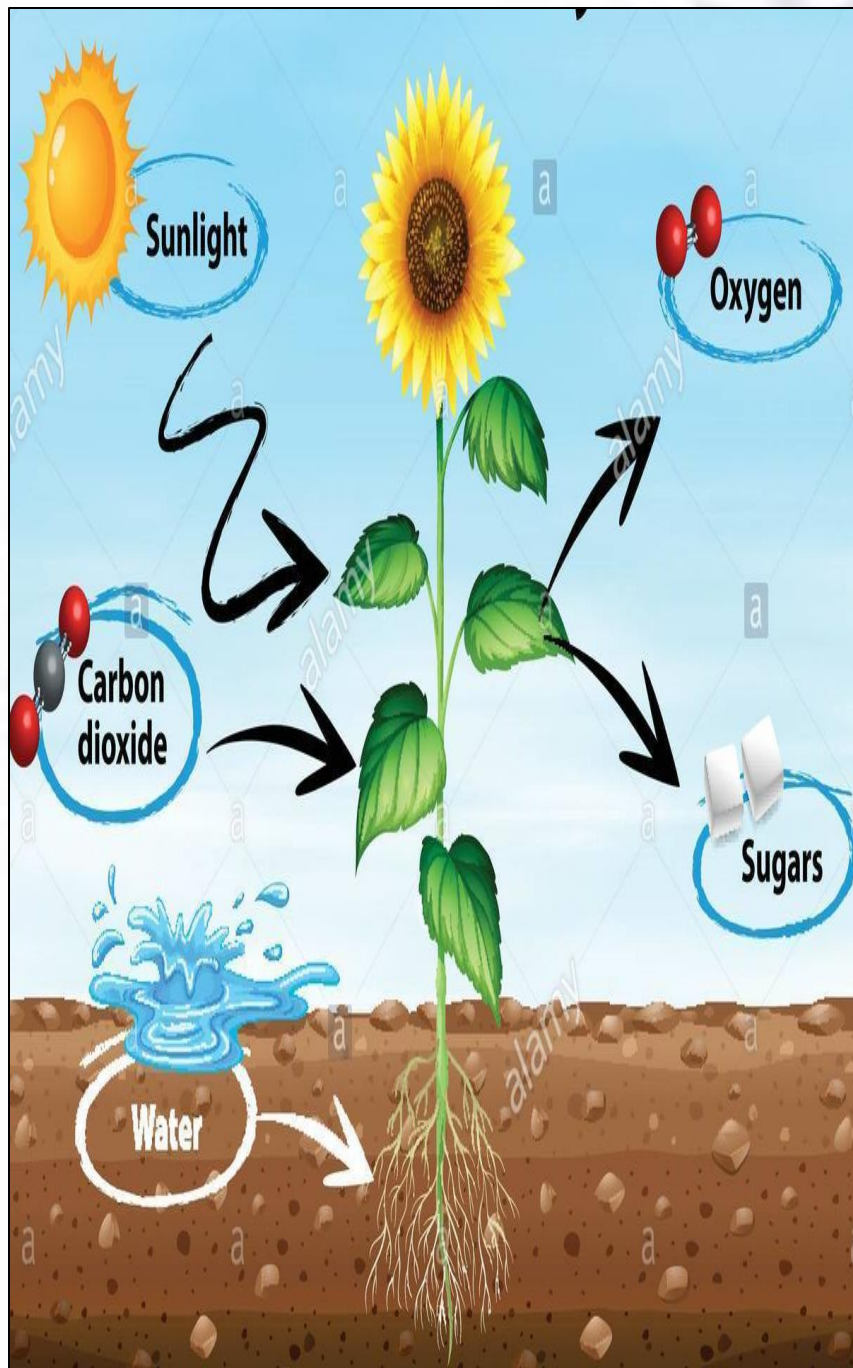
- The simplest bacterial cell is capable of hundreds of different chemical transformations, none of which occurs at any significant rate in the inanimate world.
- Virtually all chemical changes that take place in cells require *enzymes*—molecules that greatly increase the rate at which a chemical reaction occurs. The sum total of the chemical reactions in a cell represents that cell's metabolism.



❑ Cells reproduce themselves

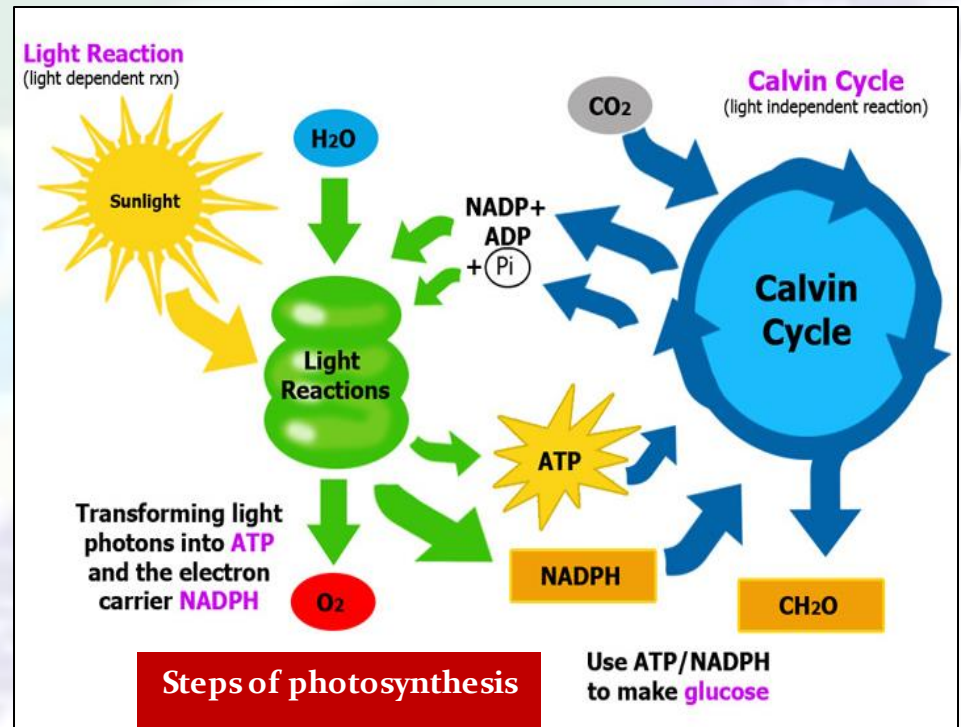
- Just as individual organisms are generated by reproduction, so too are individual cells.
- Cells reproduce by division, a process in which the contents of a “mother” cell are distributed into two “daughter” cells.
- Prior to division, the genetic material is faithfully duplicated, and each daughter cell receives a complete and equal share of genetic information.
- The two daughter cells have approximately equal volume.





❑ Cells acquire and utilize energy

- Every biological process requires the input of energy.
- All organisms use a source of energy for their metabolic activities.
- Some organisms capture energy from the sun and convert it into chemical energy in food; others use chemical energy in molecules they take in as food.



❑ Cells are capable of self regulation

- Even the smallest cell are complex and require multiple regulatory mechanisms to coordinate internal functions, respond to stimuli, and cope with environmental stresses.
- Cells are robust, that is, hearty or durable, because they are protected from dangerous fluctuations in composition and behavior.
- The importance of a cell's regulatory mechanisms becomes most evident when they break down. For example, failure of a cell to correct a mistake when it duplicates its DNA may result in a debilitating mutation, or a breakdown in a cell's growth-control safeguards can transform the cell into a cancer cell with the capability of destroying the entire organism.

❑ Cells are carry out mechanical activities

- Cells are sites of bustling activity.
- Materials are transported from place to place, structures are assembled and then rapidly disassembled, and, in many cases, the entire cell moves itself from one site to another.
- These types of activities are based on dynamic, mechanical changes within cells, many of which are initiated by changes in the shape of “motor” proteins.
- Motor proteins are just one of many types of molecular “machines” employed by cells to carry out mechanical activities.

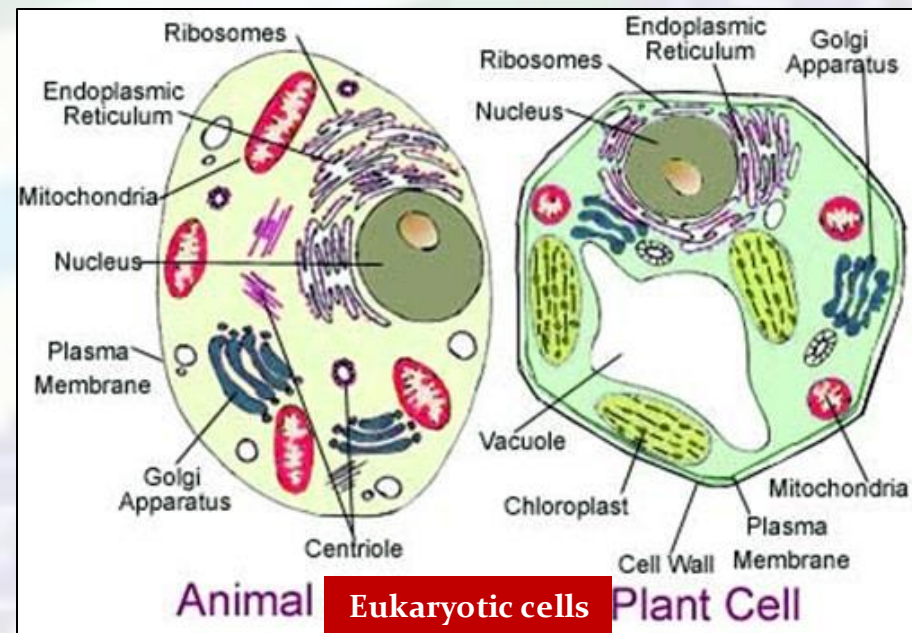
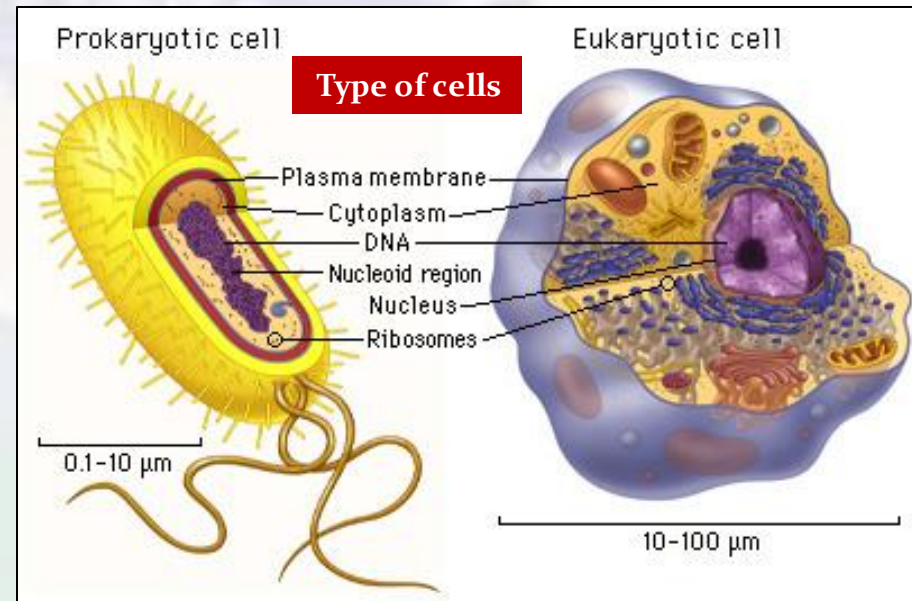
NATURE AND FUNCTIONS OF CELL

- ❖ There are many different types, sizes, and shapes of cells in the body.
- ❖ For descriptive purposes, the concept of a "generalized cell" is introduced. It includes features from all cell types.
- ❖ A cell consists of three parts: the cell membrane, the nucleus, and, between the two, the cytoplasm.
- ❖ Within the cytoplasm lie intricate arrangements of fine fibers and hundreds or even thousands of miniscule but distinct structures called organelles.
- ❖ Cell is enclosed by a plasma membrane, which forms a selective barrier that allows nutrients to enter and waste products to leave.
- ❖ It maintains the integrity of a cell and controls passage of materials into and out of the cell.
- ❖ All materials within a cell must have access to the cell membrane (the cell's boundary) for the needed exchange.
- ❖ The interior of the cell is organized into many specialized compartments, or organelles, each surrounded by a separate membrane.
- ❖ The nucleus is the control center of the cell.
- ❖ The nucleus, contains the genetic information necessary for cell growth and reproduction.
- ❖ The nucleus determines how the cell will function, as well as the basic structure of that cell.
- ❖ Each cell contains only one nucleus, whereas other types of organelles are present in multiple copies in the cellular contents, or cytoplasm.

- ❖ Organelles include mitochondria, responsible for the energy transactions.
- ❖ Lysosomes, which digest unwanted materials within the cell.
- ❖ Endoplasmic reticulum and the Golgi apparatus, play important roles in the internal organization of the cell by synthesizing selected molecules and then processing, sorting, and directing them to their proper locations.
- ❖ In addition, plant cells contain chloroplasts, which are responsible for photosynthesis, whereby the energy of sunlight is used to convert molecules of carbon dioxide (CO_2) and water (H_2O) into carbohydrates.
- ❖ Between all these organelles is the space in the cytoplasm called the cytosol.
- ❖ The cytosol contains an organized framework of fibrous molecules that constitute the cytoskeleton, which gives a cell its shape, enables organelles to move within the cell, and provides a mechanism by which the cell itself can move.
- ❖ The cytosol also contains more than 10,000 different kinds of molecules that are involved in cellular biosynthesis, the process of making large biological molecules from small ones.
- ❖ Specialized organelles are a characteristic of cells of organisms known as eukaryotes.
- ❖ In contrast, cells of organisms known as prokaryotes do not contain organelles and are generally smaller than eukaryotic cells.
- ❖ However, all cells share strong similarities in biochemical function.
- ❖ No matter which type of cell we are considering (prokaryotic or eukaryotic), all cells have certain features in common, such as a cell membrane, genetic material, cytoplasm, and ribosomes.

TYPE OF CELLS

- ❖ Life exhibits varying degrees of organization.
- ❖ Based upon the origin and development, cells fall into two major groups:
 - Prokaryotes (bacteria, blue-green algae)
 - Eukaryotes (plant and animal cell)
- ❖ The term prokaryotic and eukaryotic were given by Hans Ris in the early 1960's.
- ❖ Any cellular organism may have only one kind of cell either prokaryotic or eukaryotic.
- ❖ Prokaryotic cells are usually more primitive, smaller, simple, and lack of the internal compartmentalization.
- ❖ Eukaryotic cells have a great variety of organelles and well internal organization.
- ❖ Prokaryotes are single-celled organisms, while eukaryotes can be either single-celled or multicellular.



Differences between Prokaryotic and Eukaryotic cell

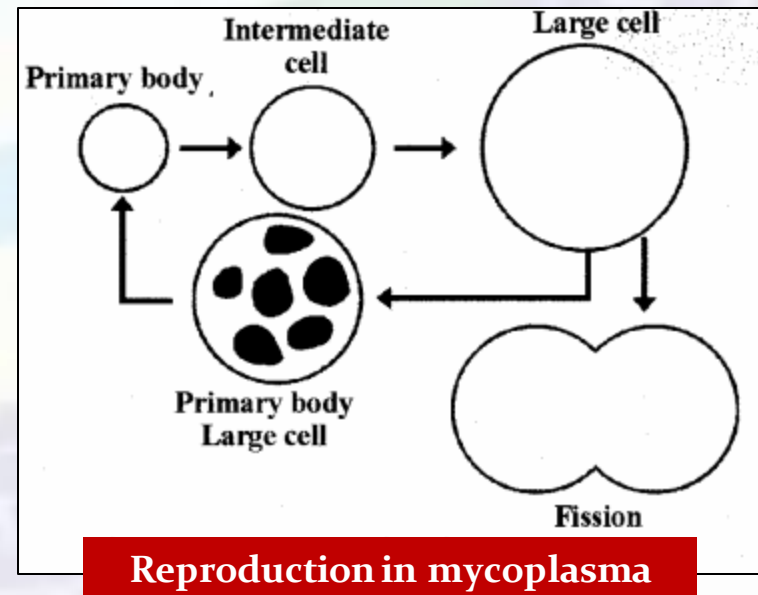
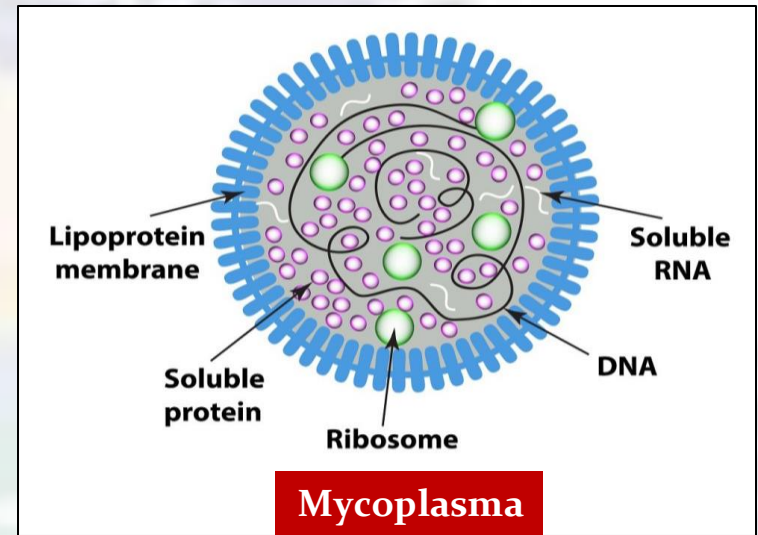
	Properties	Prokaryote	Eukaryote
Basics	Size	Generally small < 2 µm in diameter	Usually larger. 2 to 100µm in diameter
	Origin	Most primitive	Relative new, or evolved from the prokaryote
	Phylogenetic group	Bacteria, Archaea	Algae, fungi, protozoa, plnt and animal cell
Forms of motility	Flagellar movement	Flagella composed of single type of protein arrange in a fiber; flagella rotate	Flagella or cillia; composed of microtubues; do not rotate
	Nonflagellar movement	Gliding motility; gas vesicle mediated	Cytoplasmic streamlining and ameboid movement; gliding motility
Nuclear structure and function	Nuclear membrane	Absent	Present
	Nucleolus	Absent	Present
	DNA	Single molecule generally covalently closed and circular, not complexed with histones	Linear, present in several chromosomes, usually complexed with histones.
	Division	No mitosis	Mitosis, mitotic apparatus with microtubular spindle
	Sexual reproduction	Fragmentary process, unidirectional, no meiosis, usually only portions of genetic complement reassorted	Regular process, meiosis reassortment whole chromosome complement
	Introns in genes	Rare	Common
Cytoplasmic structure and organization	Cytoplasmic membrane	Usually lacks sterols: hopanoids may be present	Sterols usually present; hopanoids absent
	Internal membrane	Relative simple, limited to specific group	Complex, endoplasmic reticulum and Golgi complex
	Ribosomes	70S in size	80S, excepts for ribosome of mitochondria and chloroplasts, which are 70S
	Membranous organelles	Absent	Several present
	Photosynthetic pigments	In internal membranes of chromosomes, chloroplast are absent	In chloroplasts
	Respiratory system	Part of cytoplasmic membrane	In mitochondria
	Cell wall	Present (in most), composed f peptidoglycan (bacteria), other polysaccharides, protein, glycoprotein	Present in plant, algae, fungi, usually polysaccharid, absent in animals and most protozoa
	Endospores	Present (in some), very heat resistant	Absent
	Gas vesicles	Present (in some)	Absent

Prokaryotic cell

- ❖ Prokaryotic cells may be defined as the cells which do not have a true nucleus or membrane-bound organelles. Organisms that possess such kind of cells are known as prokaryotes.
- ❖ They are typically unicellular in organization (Nelson and Cox 2005). For example: Archaea, bacteria, pleuropneumonia like organisms (PPLo), blue green algae.
- ❖ The prokaryotic (Gr., *pro-* primitive, *karyon-* nucleus) cells are the most primitive type of cells exist in this earth from the morphological point of view.
- ❖ These are the simplest and mostly small sized (1-10 μm) cells. As its name indicated, the nucleus are primitive type or true nucleus are absent. The cell comprise a central nuclear components, sometime called nucleoid (resemble like nucleus, but not true nucleus) which contain their vital biomolecules (nuclear protein, DNA and RNA molecules) surrounded by the cytoplasmic ground substance, with the whole covered by a plasma membrane.
- ❖ Neither the nuclear apparatus nor the respiratory enzyme systems are separately enclosed by membrane. However the inner surface of the plasma membrane itself may serve for enzyme attachment.
- ❖ The cytoplasm of such kind of cells, lack in well-defined cytoplasmic organelles (endoplasmic reticulum, mitochondria, centrioles, golgi bodies etc).
- ❖ Reproduction is take place by the vegetative means i.e., Binary fission and budding
- ❖ Sexual reproduction is usually absent, if present unidirectional transfer of genes from donor to recipient is take place.
- ❖ The mode of nutrition is principally absorption type. However, some blue green algae synthesized their own food due to the presence of photosynthetic pigments.

Pleuropneumonia like organisms (PPLO): A Prokaryotic cell

- ❖ The Pleuropneumonia like organisms or PPLOs are the simplest known prokaryotic cells. They are small in size (0.1-0.3 μm) and having deformable plasma membrane around their cell. PPLO resemble to the bacteria cell which differ with only in the absence of cell wall and mesosomes. Therefore, they are placed excluded from the group of bacteria. In size, the PPLOs overlapped with the largest viruses and with the smallest bacteria. *Mycoplasma* is the widely studies genus of the PPLO.
- ❖ The cell of PPLO restricted by a thick (75 A°) plasma membrane. The granulated ground material called cytoplasm contains vacuoles of undefined significance. At the end of the cell, a bud like structure called bleb is present with less known function. The genetic material (DNA=fibrils form or a single circular double helix) is limited in nuclear region and not enclosed by nuclear membrane. The nuclear region is encircled by many ribosomes and other components involved in protein synthesis.
- ❖ In PPLO the reproduction is take place by the method of budding, binary fission, formation of tiny spore.



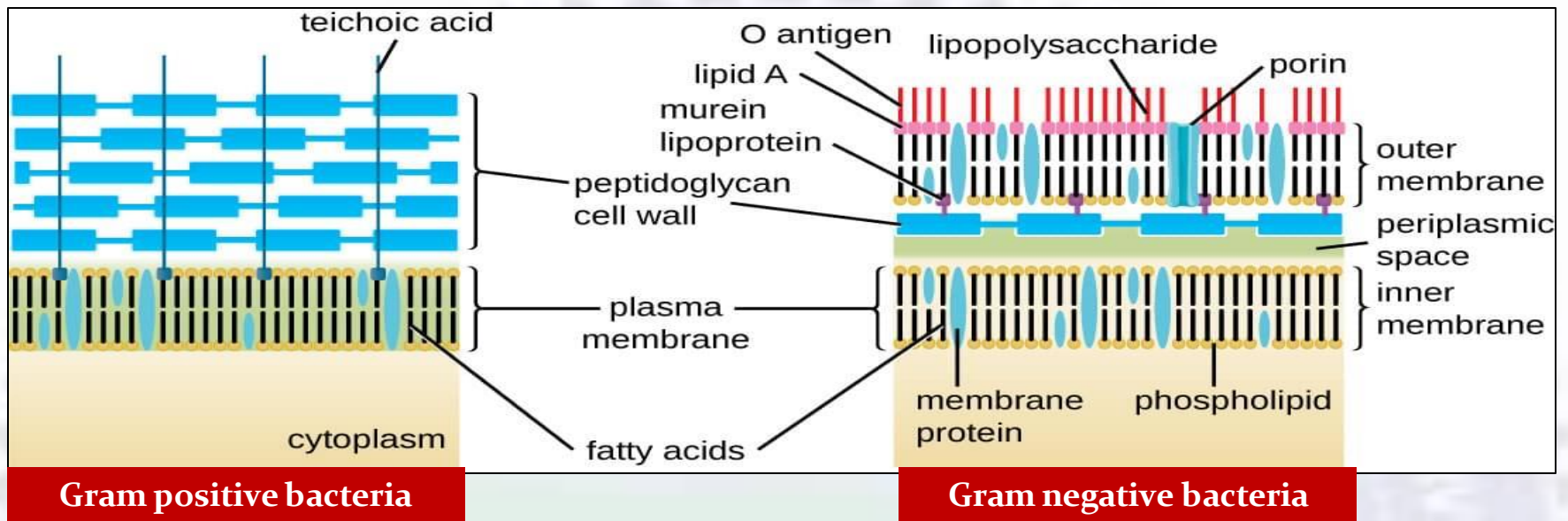
Bacteria cell: A Prokaryotic cell

- ❖ All bacteria basically comprises as prokaryotic cells in their body. A typical bacterial cell is made up of following cell organization:

❑ **Outer covering:** The outer covering of the bacterial cell is possess three layers i.e.,

- **Layer 1: Capsule:** It is the outermost, additional protective layer of the bacterial cell which is slimy in nature and made up of polysaccharides.
- **Layer 2: Cell wall:** After the capsule, a rigid and strong layer is present known as cell wall. The cell wall besides containing protein, lipids, carbohydrates, phosphorus and certain inorganic salts, also contains an amino acid diaminopimelic acid (only in bacteria and blue green algae) and a derivative of glucose known as muramic acid. The Bacterial cell walls are made of peptidoglycan which is made up of polysaccharide chains cross-linked by unusual peptides containing D-amino acids (Koch 2003). Therefore the cell wall of bacteria is different from the plant and fungi. In plant and fungi cell walls are made up of cellulose and chitin, respectively.

The bacterial cell wall can divided into two category i.e., gram positive and gram negative according to differences in their cell wall. Gram-positive bacteria possess a thick cell wall containing many layers of peptidoglycan, teichoic acids and a traces of RNA. In contrast, gram-negative bacteria have a relatively thin cell wall consisting of a few layers of peptidoglycan surrounded by a second lipid membrane containing lipopolysaccharides and lipoproteins. They do not contain teichoic acids and RNA.

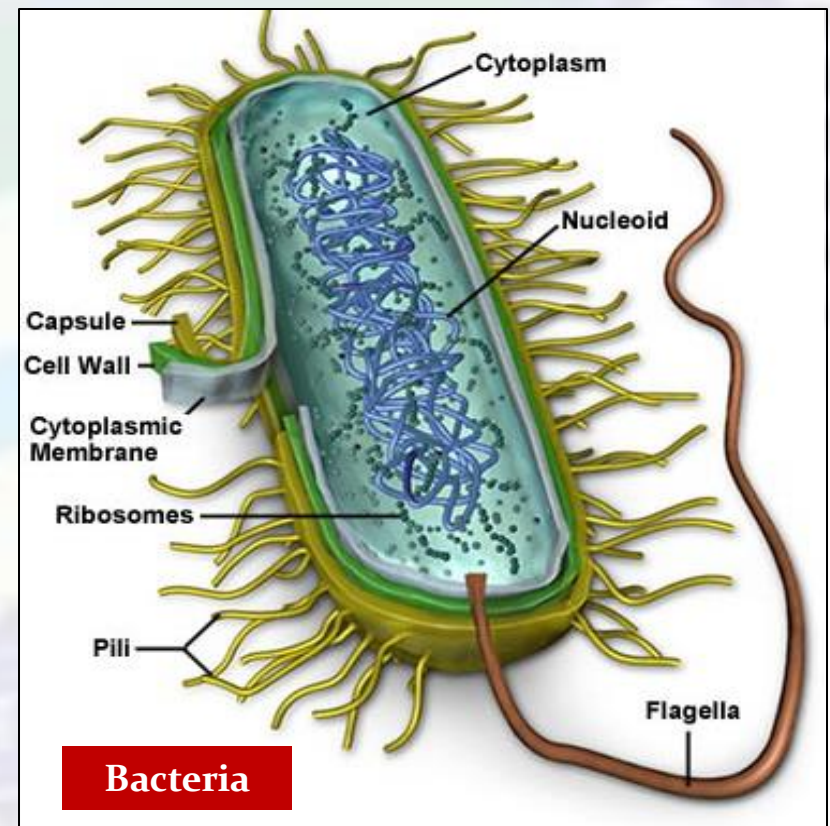


- **Layer 3: Plasma membrane:** Just after the cell wall, a thin layer surrounded the whole cytoplasm. This thin layer membrane is called plasma membrane or cytoplasmic membrane. This layer functioned as a selective permeability barrier that regulates the passage of substances into and out of the cell. The bacterial membrane allows passage of water and uncharged molecules up to molecular weight of about 100 daltons, but does not allow passage of larger molecules.

This membrane also contains the oxidative or respiratory enzymes which have the similar functions as mitochondria in eukaryotic cells. The plasma membrane is composed of a phospholipid bilayer. Bacterial membranes are composed of 40 % phospholipid and 60 % protein. The phospholipids are amphiphilic molecules with a polar hydrophilic glycerol "head" attached via an ester bond to two nonpolar hydrophobic fatty acid tails, which naturally form a bilayer in aqueous environment.

❑ Cytoplasm:

- The bacterial cytoplasm is a viscous, dense, colloidal and granulated material.
- Cell organelles are absent. However, no membrane bound ribosomes are occurred.
- DNA molecule or bacterial chromosome is considered as the genetic material.
- Certain bacteria are able to do photosynthesis with the help of a pigment called bacteriochlorophyll, associated with the internal membrane.
- A thread like structure called flagella, help in the locomotion. Generally, rod and spiral shaped bacteria regularly contain flagella while it is entirely absent in spherical bacteria.
- Some bacteria also possess a hair like out growth called pili or fimbriae responsible for recognizing and attaching to the host.
- Sex pili in male strain play a role to make a bridge with the female cell during mating.

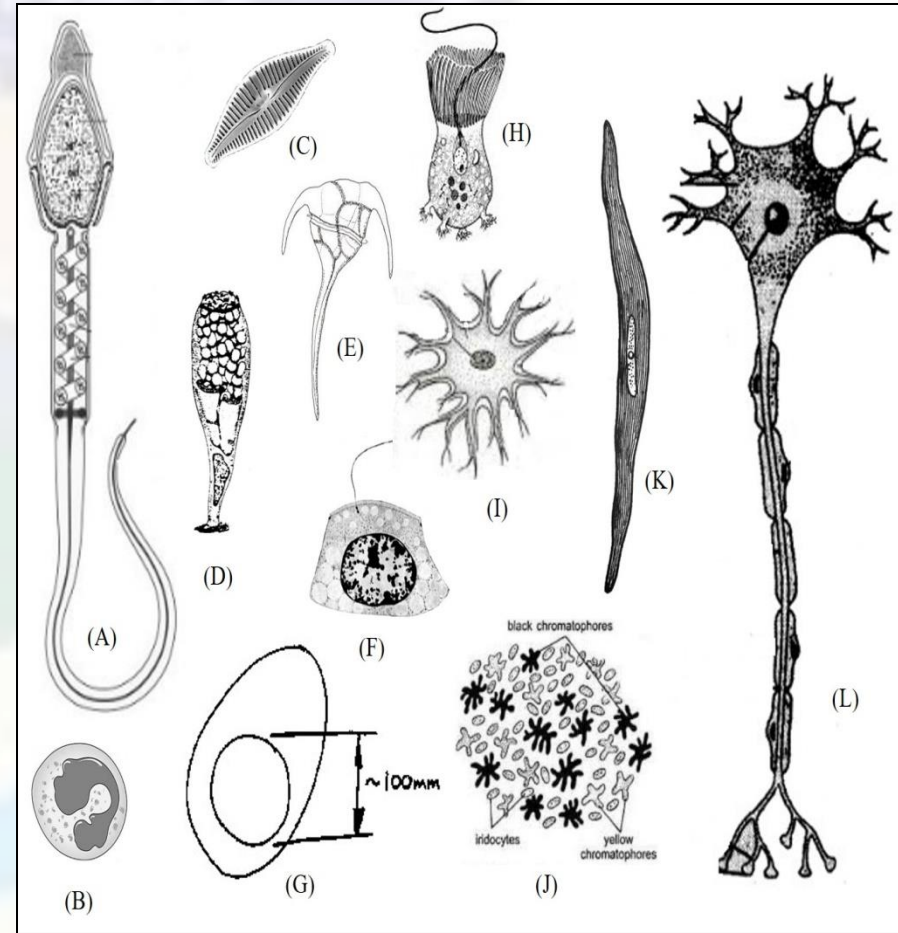


Eukaryotic cell

- ❖ Eukaryotes represent a tiny minority of all living things. However, due to their generally much larger size, their collective worldwide biomass is estimated to be about equal to that of prokaryotes (Whitman et al. 1998).
- ❖ Eukaryotes evolved approximately 1.6–2.1 billion years ago, during the Proterozoic eon. These are the advanced type of cells which may be derived or evaluated from the prokaryotic cells.
- ❖ The eukaryotic (Gr., *eu-* well or true, *Karyotic*-nucleus) cells are those cells which contain a well-constructed nucleus (nucleus enclosed within the membrane) and membrane bounded cell organelles.
- ❖ Organisms that possess such kind of cells are known as eukaryotes. They are mostly multicellular in organization (Nelson and Cox 2005) which include organisms consisting of many cell types forming different kinds of tissue. For example: protozoa, animal cell, plant cells, fungi etc.
- ❖ Eukaryotes possess the true nuclear, which contains chromatin fibres, nucleoplasm, nucleolus etc. remain separated from the cytoplasm by the thin perforated nuclear membranes. Apart from the true nucleus, eukaryotic cells also possess some other membrane-bound organelles such as endoplasmic reticulum, golgi apparatus, mitochondria etc. In addition, group of photosynthesis plants also contain chloroplasts.
- ❖ The process of reproduction is take place by both asexual and sexual in eukaryotes. They can reproduce asexually through mitosis and sexually through meiosis and gamete fusion. Before going to the detail of the eukaryotic cells, it is advisable to know the general characteristics of different types of eukaryotic cells.

Shape

- ❖ The eukaryotic cells exhibited various forms and shapes.
- ❖ The shape may vary with animal to animal or organ to organ. Even the cells of the same organ may display variations in the shapes. The shape of the cells may depend upon;
 - Functional adaptations of the cell.
 - Internal or external environment of the cell.
 - Mechanical stress or pressure and surface tension of the cell.
 - Viscosity of the protoplasm.
 - Mechanical action exerted by the cell.
 - Rigidity of the cell membrane.
- ❖ Typically the animal cell is spherical in shape but irregular, cylindrical, cuboidal, triangular, tubular, polygonal, oval, round elongated etc have also been seen in different organisms. Some cells (*Amaeba* and leucocytes) able to change their body shape very frequently.



Various type of eukaryotic cells exhibited diverse shapes; (A). human sperm, (B). leucocyte, (C). diatom, (D). goblet cell, (E). ceratium, (F). epithelial cell, (G). Ostrich egg, (H). choanocyte, (I). osteocyte, (J). chromatophore, (K). muscle cell, (L). nerve cell

Size

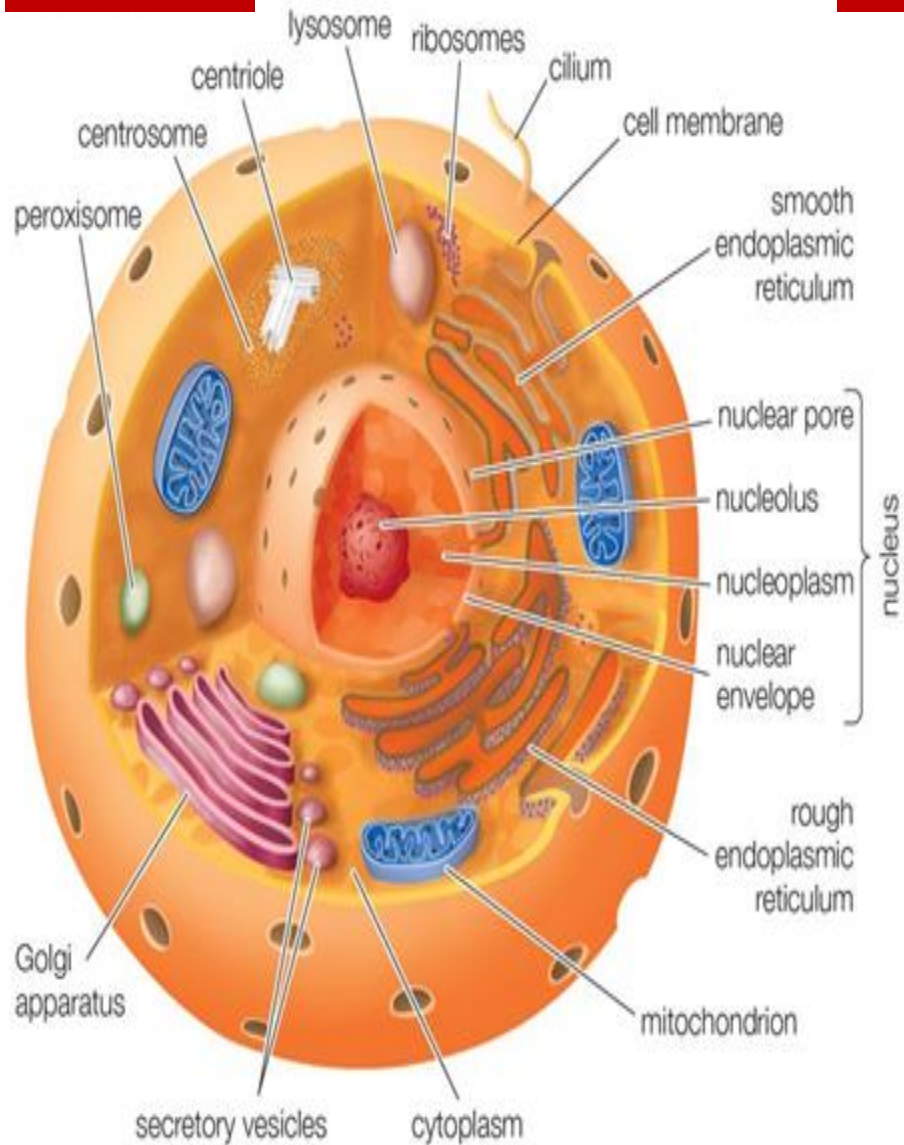
- ❖ The size of the eukaryotic cell varied from organism to organism.
- ❖ Generally, the eukaryotic cells are microscopic in nature but some animals and plant cells are easily visible by the naked eyes. For example: the egg of ostrich is the largest cell in the diameter, some nerve cells are considered more than 3-5 feet in length (Verma and Agrawal 2008). Usually, the size of cells may vary between $1\mu\text{m}$ to $175000\mu\text{m}$ (175 mm).
- ❖ Cells of humans typically have a mass 400,000 times larger than the mass of a single mycoplasma bacterium, but even human cells are only about $20\mu\text{m}$ across. It would require a sheet of about 10,000 human cells to cover the head of a pin, and each human organism is composed of more than 30,000,000,000,000 cells.

Number

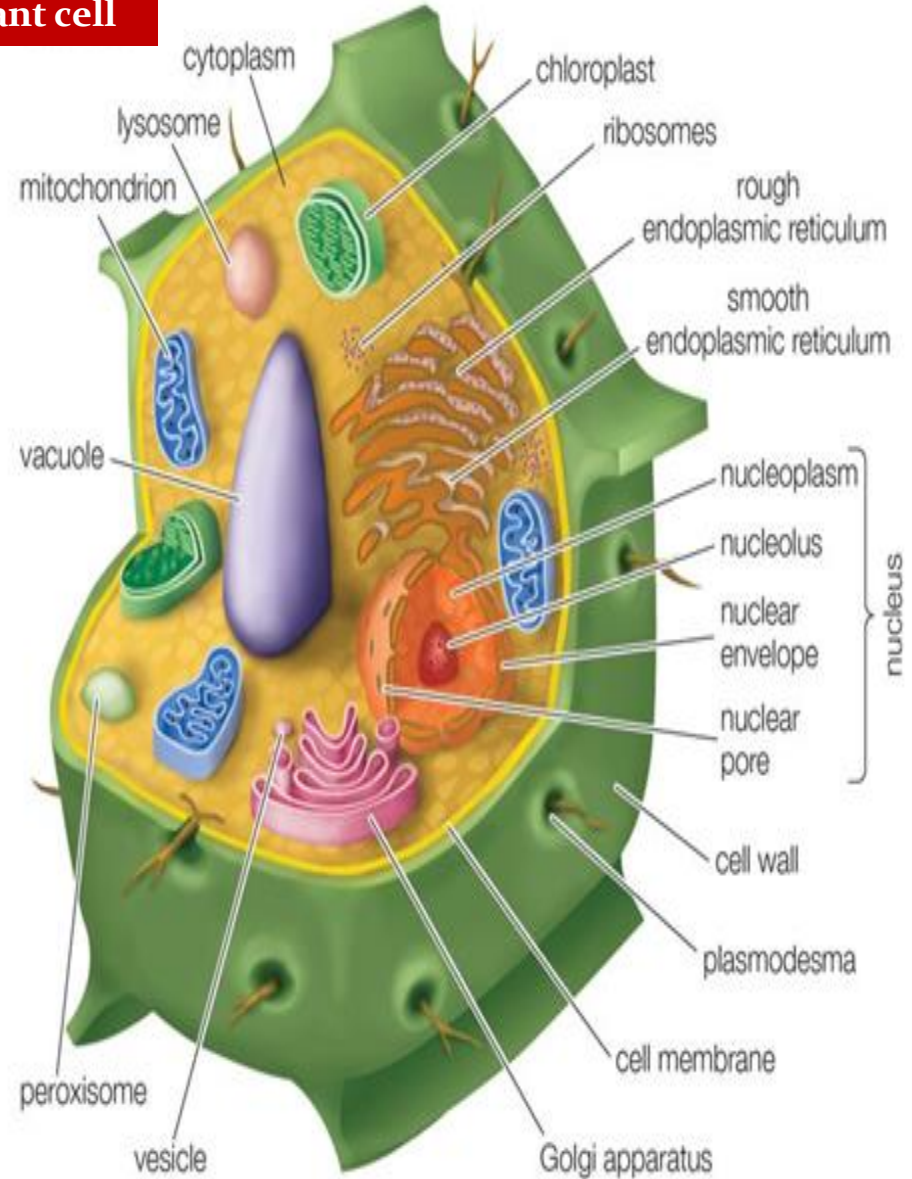
- ❖ The body of the unicellular and acellular organisms (Protozoa and Protophyta) composed by a single cell.
- ❖ Most of the eukaryotic cells have many cells in the body therefore known as multicellular organisms.
- ❖ The numbers of the cells in particular organisms are depending upon the size of the organisms. Larger size have the great number of the cells in their body. The number of cells in eukaryotic organisms varies from single cell to trillions. Example: in the unicellular organisms a single cell is present however, the human body contain approximately 26 trillions of cells, 5 million erythrocytes cells per cubic ml in blood and 10 billion neurons in nervous system.

Type of Eukaryotic cells

Animal cell



Plant cell



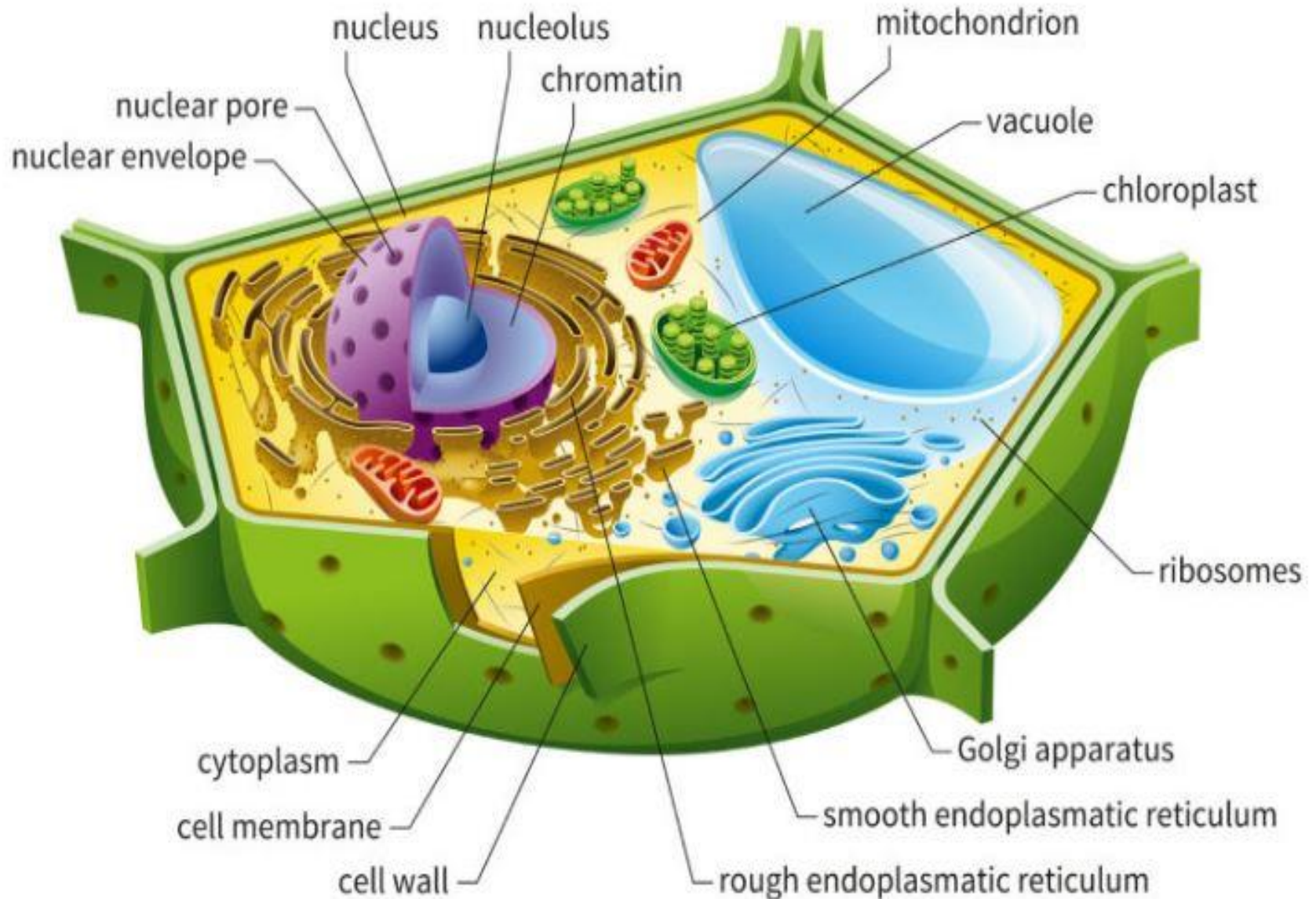
Differences between Animal and Plant cell

- ❖ **Shape and Size:** Plant cells are 10-100 micrometers in length, typically rectangular or cubic in shape, however animal cells are 10-30 micrometers in length and irregular in shape.
- ❖ **Energy store:** Animals cells store energy in the form of the complex carbohydrate glycogen. Plant cells store energy as starch.
- ❖ **Differentiation:** In animal cells, only stem cells are capable of converting to other cell types. Most plant cell types are capable of differentiation.
- ❖ **Growth:** Animal cells increase in size by increasing in cell numbers. Plant cells mainly increase cell size by becoming larger, by absorbing more water into the central vacuole.
- ❖ **Cell Wall:** Animal cells do not have a cell wall but have a cell membrane. Plant cells have a cell wall composed of cellulose as well as a cell membrane.
- ❖ **Centrioles:** Animal cells contain these cylindrical structures that organize the assembly of microtubules during cell division. Plant cells do not typically contain centrioles.
- ❖ **Lysosomes:** Animal cells possess lysosomes which contain enzymes that digest cellular macromolecules. In plant cells vacuole handles molecule degradation.
- ❖ **Plastids:** Animal cells do not have plastids. Plant cells contain plastids such as chloroplasts, which are needed for photosynthesis.
- ❖ **Plasmodesmata:** Animal cells do not have plasmodesmata. Plant cells have plasmodesmata, which are pores between plant cell walls that allow molecules and communication signals to pass between individual plant cells.
- ❖ **Vacuole:** Animal cells may have many small vacuoles. Plant cells have a large central vacuole that can occupy up to 90% of the cell's volume.

Structure of Plant cell

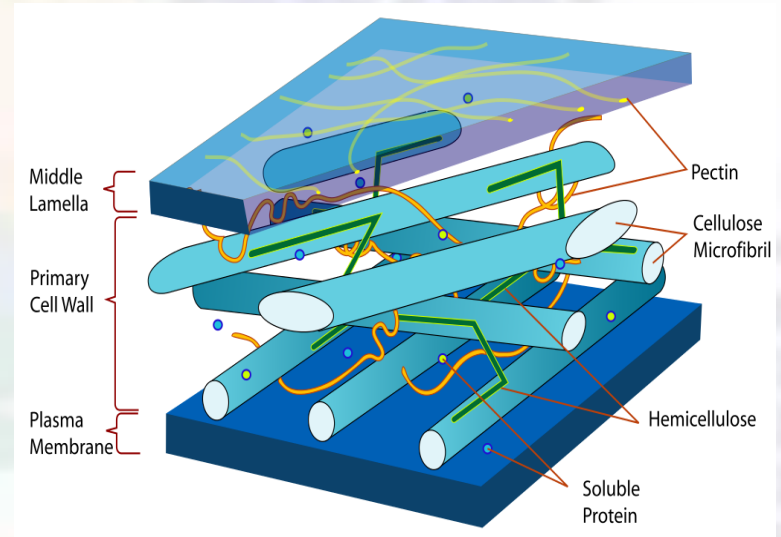
- ❖ Plant cells are the basic unit of life in organisms of the kingdom Plantae.
- ❖ They are eukaryotic cells, which have a true nucleus along with specialized structures called organelles that carry out different functions.
- ❖ Their distinctive features include primary cell walls containing cellulose, hemicelluloses and pectin.
- ❖ A large vacuole that regulates turgor pressure allows plants to grow tall.
- ❖ The absence of flagella or centrioles, except in the gametes, and a unique method of cell division involving the formation of a cell plate or phragmoplast that separates the new daughter cells.
- ❖ Plants are considered autotrophic because they produce their own food and do not have to consume any other organisms.
- ❖ The plant cell has many different internally to many parts. Each part of the cell has a specialized function. These structures are called organelles.
- ❖ The plant cells are well defined cell. Therefore, we can categorized the cell in the following components:
 - Cell wall and plasma membrane
 - Cytoplasm
 - Nucleus

Structure of Plant cell



❑ Cell wall and plasma membrane

- ❖ Usually, the plant cell wall is composed of the polysaccharide cellulose, hemicellulose and pectin. Some polymers (lignin, suberin and cutin) are also embedded in plant cell wall. The plant cell wall divided into three layers
 - **Primary cell wall:** A thin and flexible layer formed while the cell is growing
 - **Secondary cell wall:** A thick layer formed inside the primary cell wall after the cell is fully grown. E.g., xylem, possess a secondary wall containing lignin.
 - **Middle lamella:** A layer rich in pectins. This outermost layer forms the interface between adjacent plant cells and glues them together.
- ❖ The composition of fungal cell wall is quite different from the plant which is made up of N-acetylglucosamine polymer chitin.
- ❖ **Functions:** Provide shape, support, strength, rigidity, and protection against mechanical/biological stress. The cell wall of certain plants possesses the pit like small apparatus known as plasmodesmata, help to connect the cell to the adjacent cell.
- ❖ The cells have an external covering of living, thin, porous and semipermeable cells known as plasma membrane or cell membrane. This membrane is composed by three layers in which the inner and outer layers are constituted by protein and middle layer by lipid. Technically, it is selectively permeable to ions and organic molecules thus regulate the movement of substances in the cells.



□ Cytoplasm

- ❖ The cytoplasm can be divided into (1). cytoplasmic matrix and (2). cytoplasmic structures
- **Cytoplasmic Matrix:** The space between the plasma membrane and the nucleus is occupied by the gel like, translucent and homogenous colloidal liquid known as cytoplasmic matrix or hyaloplasm.
- ❖ The 90 % of the cytoplasm is constituted by water. Remaining 10 % is constituted by the various inorganic compounds including salts of Na, K and minerals, organic compounds such as carbohydrates, lipids, fats, proteins, vitamins, nucleoproteins, nucleic acids (RNA and DNA) and enzymes.
- ❖ The peripheral region of cytoplasmic matrix is comparatively non granular, viscous, clear and rigid as known as the plasmagel, cortex or cortical layer and ectoplasm.
- ❖ On the other hand the inner region is granular, less viscous and known as endoplasm.
- ❖ **Functions:**
 - ✓ Conduct the various vital activities of the cells.
 - ✓ Biosynthesis of biochemical substances (proteins, carbohydrates, proteins, nucleic acid etc).
 - ✓ The process of glycolysis, anaerobic respiration and pentose pathway type of respiration occur in the matrix part of cytoplasm.
 - ✓ The cell organelles exchange materials through the cytoplasmic matrix.
 - ✓ It is autonomic and is called cytoplasmic or protoplasmic streaming.
 - ✓ This helps in distribution of various materials inside the cell.

➤ **Cytoplasmic Structures:** In matrix some non-living and living substances are suspended.

(i). **Cytoplasmic inclusions:** The non living substances (stored, secretory and excretory substances) of the cell remain suspended in the cytoplasmic matrix in the form of granules which forming the cytoplasmic inclusions. The cytoplasmic inclusions may be classified into the three main groups:

- **Reserved Products:** Carbohydrate, fats and protein
- **Secretory Products:** nectar, coloring material (pigments), hormones and enzymes, etc.
- **Excretory Products:** Mineral crystals, Tannins, Essentials oils, Resins, Gums, Latex, Alkaloids

❖ **Functions:**

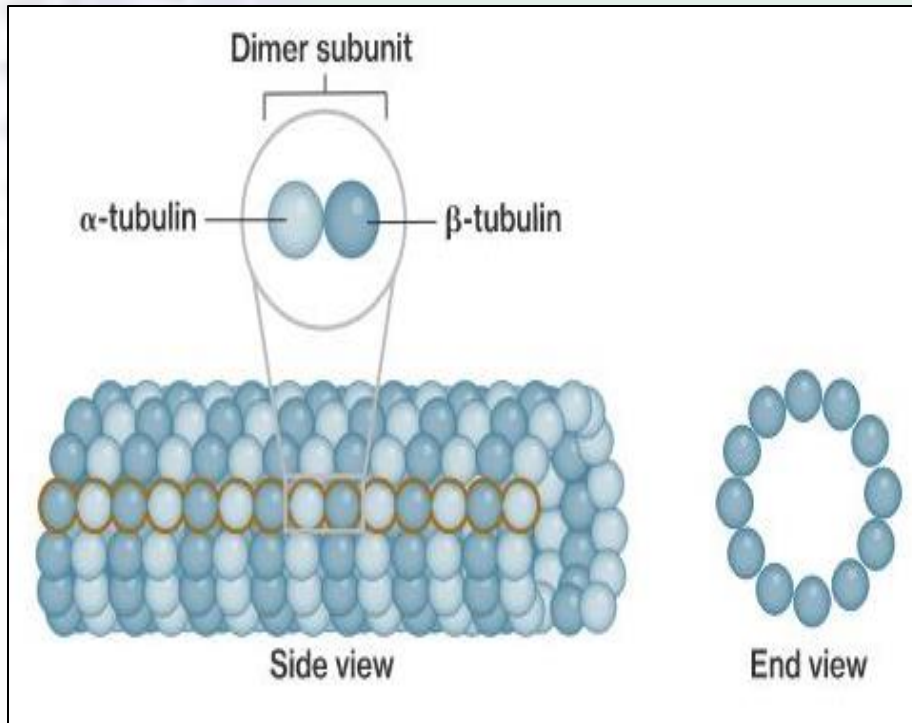
- ✓ These substances aid the organism in defense.
- ✓ It does maintenance of the cellular structure.
- ✓ It helps to store various materials.
- ✓ Some inclusions such as hormones, enzymes, etc. influence the metabolism, growth, and development of plant bodies.
- ✓ Inclusions like nectar attract the insects for pollination.
- ✓ Tannins play a role in protection from predation and might help in regulating plant growth.
- ✓ The resin of plants protects the plant from pathogens and insects.

(ii). **Cytoplasmic organelles:** The organelles are the living structure of the cytoplasm.

- ❖ They perform various important biosynthesis and metabolic activities such as respiration, transportation, support, storage and reproduction.
- ❖ Some most important cell organelles are discussed here:

➤ Microtubules

- ❖ Microtubules are small, hollow, bead-like pipes or tubes with walls constructed in a circle of 13 protofilaments that consist of polymers of tubulin and globular protein.
- ❖ Each protofilament is composed of longitudinally stacked heterodimers of α - and β -tubulins.
- ❖ With diameters of only 25 nanometers, microtubules often disband and reform as quickly as the cell needs them to.
- ❖ The half-life of tubulin is only about a day, but a microtubule may exist for only 10 minutes as they are in a constant state of instability. This type of instability is called dynamic instability, and microtubules can assemble and disassemble in response to the cell's needs.



Functions:

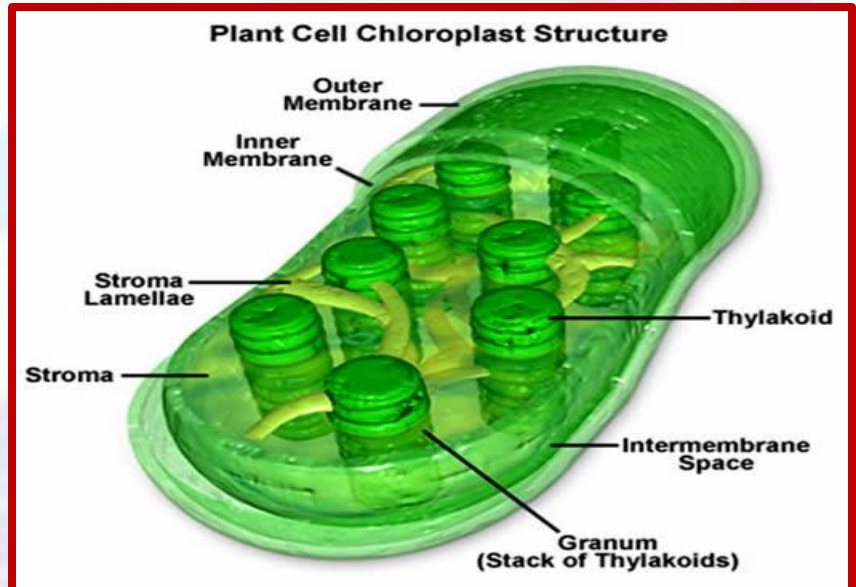
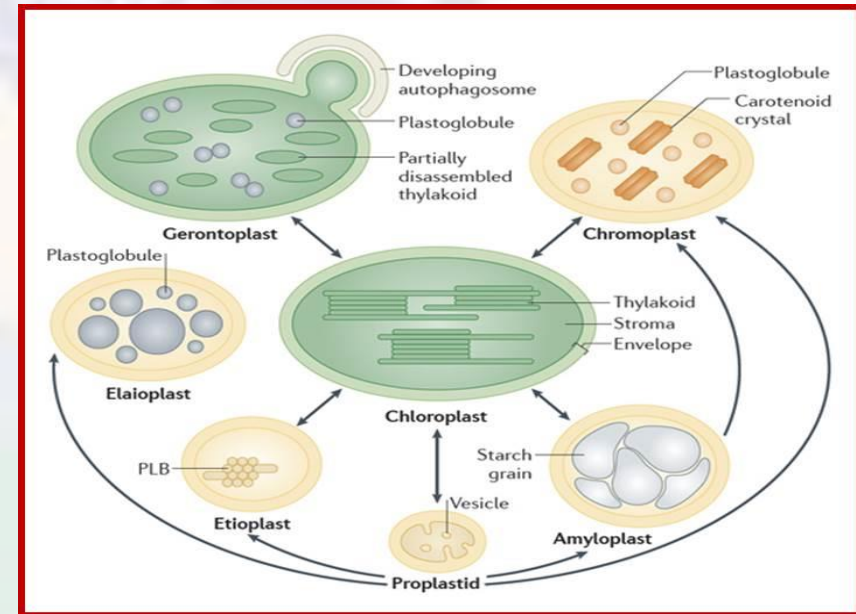
- ✓ Help, support and give shape to the cell.
- ✓ They also serve a transportation function.
- ✓ Together with the microfilaments and intermediate filaments, form the cytoskeleton.
- ✓ The microtubules also play a very important role during cell division.
- ✓ Microtubules also play a part in forming large structures on the outside of the cells.
- ✓ It combine in very specific bundles to form cilia and flagella for cell movement.

➤ Plastids

- ❖ Plastids are known as the “*kitchen of the cell*”.
- ❖ The plastids exhibit only in plant cells and completely absent in animal cells.
- ❖ They give the particular colour to the plants.
- ❖ The size of plastids range from 4 to 6 μm and colour from colorless to many colours.
- ❖ The colourless plastids are known as leucoplast.

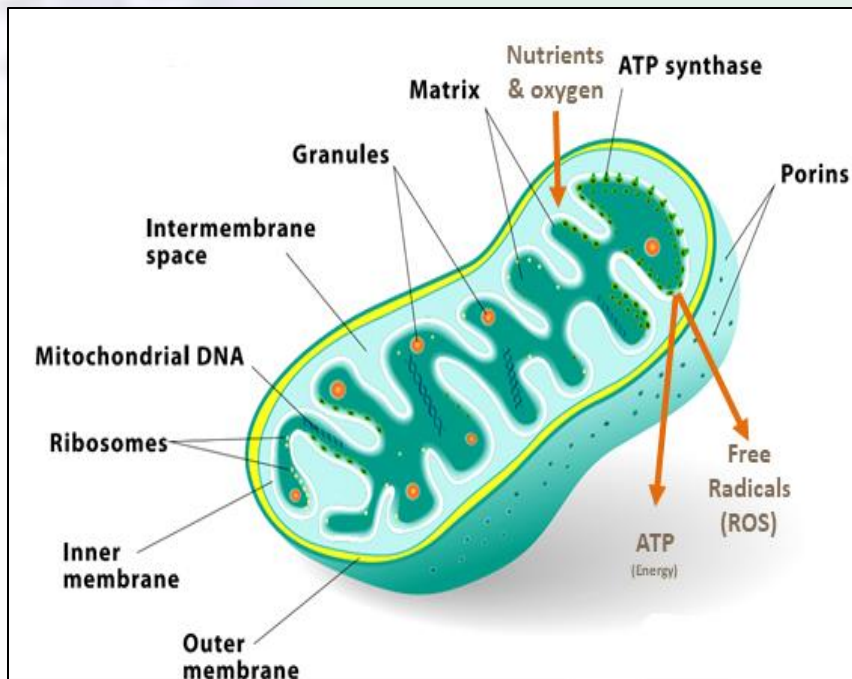
❖ Functions:

- ✓ They functions specially for the storage of starch, lipids and proteins, therefore, they called amyloplasts, lipoplasts and proteinoplasts, respectively.
- ✓ The coloured or pigmented plastids commonly called as chromoplast occurred in many colours, in which the green is the most common.
- ✓ The green coloured plastid is known as chloroplasts which help in the biosynthesis of food by the process of photosynthesis.
- ✓ The chloroplasts have complicated organization and contain DNA, ribosomes and complete protein synthesis machinery.



➤ Mitochondria

- ❖ Mitochondria named the “*power house of the cell*”.
- ❖ The shape, size and number of mitochondria varied from cell to cell. Generally they are rod and round shaped having double membrane bound structure.
- ❖ Both the inner and outer layer along with the central region are filled with a viscous fluid known as mitochondrial matrix.
- ❖ The outer membrane forms a bag like structure around the inner membrane which gives out many finger like folds in the lumen of the mitochondria.
- ❖ The folds of the inner membrane are known as cristae.
- ❖ The matrix, outer and inner membranes possess many oxidative enzymes and coenzymes.



❖ Functions

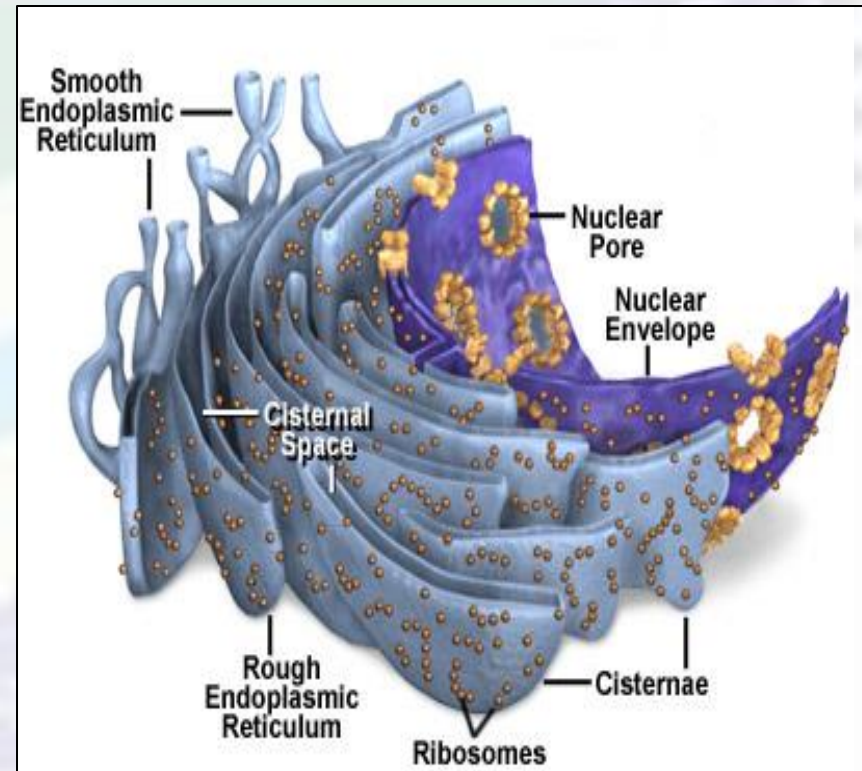
- ✓ Mitochondria are responsible for respiration, oxidation of food and metabolized the energy.
- ✓ They store the energy in it and released when it needed in the various vital activities of life.
- ✓ Mitochondria generate most of the cell's supply of adenosine triphosphate (ATP), used as a source of chemical energy (Campbell et al. 2006),

➤ Endoplasmic reticulum

- ❖ In a eukaryotic cell, endoplasmic reticulum (ER) is a reticulated organelle of the cytoplasm.
- ❖ They form an interconnected network of flattened, tubular structures known as cisternae.
- ❖ ER continues to the outer membrane of the nucleus and categorize into two types:
 - (i) Rough Endoplasmic Reticulum (RER): The ribosomes remain attached to the outer surface of RER which gives it to a rough appearance, therefore called rough endoplasmic reticulum.
 - (ii) Smooth Endoplasmic Reticulum (SER): The smooth endoplasmic reticulum lacks ribosomes.

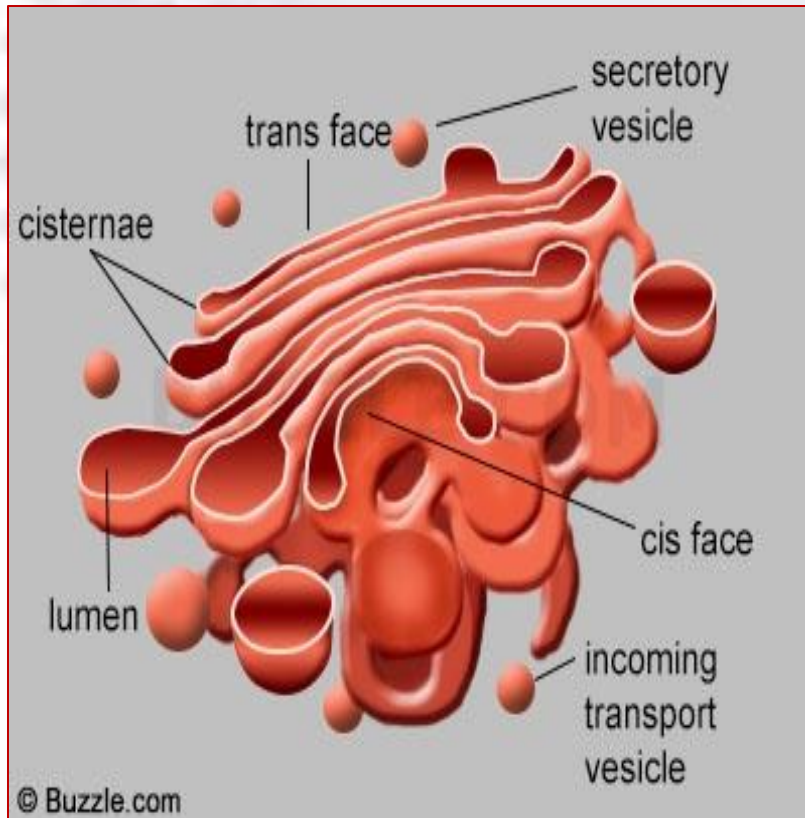
❖ Functions

- ✓ Provide the mechanical support.
- ✓ It is the sites for a number of enzymes and cytochromes to carry out specific reactions.
- ✓ Rapid synthesis of biochemicals.
- ✓ It holds various organelles in their position.
- ✓ With the help of desmotubules, ER of one cell communicates with ER of adjacent cells.
- ✓ It conducts information from outside to inside of cell and between different organelles of the same cell.
- ✓ It forms vacuoles.



➤ Golgi complex

- ❖ The Golgi complex, or Golgi body, or Golgi apparatus is a cytoplasmic organelle.
- ❖ It was discovered by Camillo Golgi in 1897.
- ❖ Golgi complex is made up of a series of compartments and is a collection of fused, flattened membrane-enclosed disks known as cisternae, originating from vesicular clusters that bud off the endoplasmic reticulum.
- ❖ Each Golgi is composed of many lamellae, tubules, vesicles and vacuoles.



❖ Functions

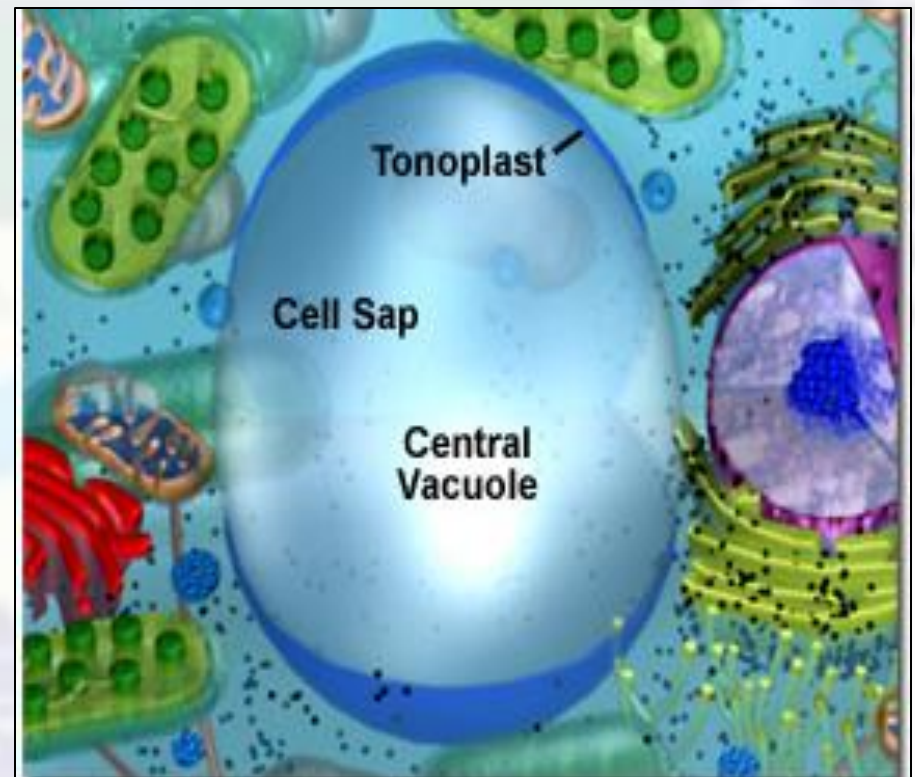
- ✓ The main function of Golgi apparatus is to carry out the processing of proteins generated in endoplasmic reticulum.
- ✓ Golgi apparatus also transports protein to the different parts of cell.
- ✓ Formation of secretory and secretion
- ✓ Help in enzyme formation
- ✓ Storage of protein
- ✓ Formation of plant cell wall
- ✓ Glycoprotein secretion
- ✓ To carry out the glycosylation and phosphorylation processes, nucleotide sugars are imported by the Golgi apparatus from cytosol.

➤ Cytoplasmic vacuole

- ❖ The vacuole is a membrane-bound, closed sacs of membranes filled with organic or inorganic molecules.
- ❖ They do not have a certain size and shape, wither cell can change them as it wants.
- ❖ The entire vacuole contains a watery substance called cell sap.
- ❖ They are much more important in plant and fungus cells than in animal cells.

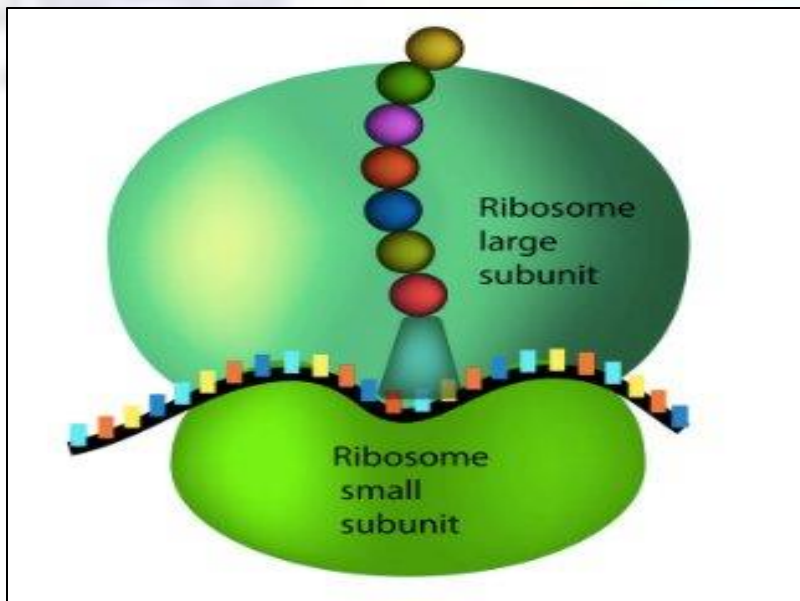
❖ Functions

- ✓ Vacuole grasp waste products, maintain amount of water in cell.
- ✓ Hydrostatic pressure or turgor steady is balanced by it in the cell.
- ✓ Maintain pH inside of the cell and hold small molecules.
- ✓ Vacuoles are also important in autophagy. In protists, vacuoles also store and help digested food. The vacuoles of the plant cells are bounded by a single, semipermeable membrane known as tonoplast. These vacuoles contain water, phenol, flavonols, anthocyanins, alkaloids, and stored product such as sugar and proteins.



➤ Ribosome

- ❖ The ribosomes are the small, spherical structured, minute organelle of cytoplasm.
- ❖ It is found in all the living organisms (including prokaryotes and eukaryotes).
- ❖ The ribosomes are originated in the nucleolus and consist of mainly the ribonucleic acids (RNA) and proteins.
- ❖ In eukaryotic cell they are attached with the membrane of endoplasmic reticulum, or occurred freely in the cytoplasm.
- ❖ The eukaryotic ribosomes are differ structurally from the prokaryotic ribosomes, however, in both the kind of cells, it is the site of protein synthesis.
- ❖ In prokaryotic cell, the ribosomes (70S type) are consist with two ribosomal subunits: the small subunits (30S) and large subunits (50S). On the other hand, the eukaryotic ribosomal subunits (80S type) are composed of 40S as small subunit and 60S as large subunit.



❖ Functions

- ✓ It is the site of protein synthesis.
- ✓ It assembles amino acid to form proteins that are essential to carry out cellular functions.
- ✓ The DNA produces mRNA and this mRNA transported to the cytoplasm for the process of protein synthesis.
- ✓ The ribosomal subunits in the cytoplasm are bound around mRNA polymers. The tRNA then synthesises proteins.

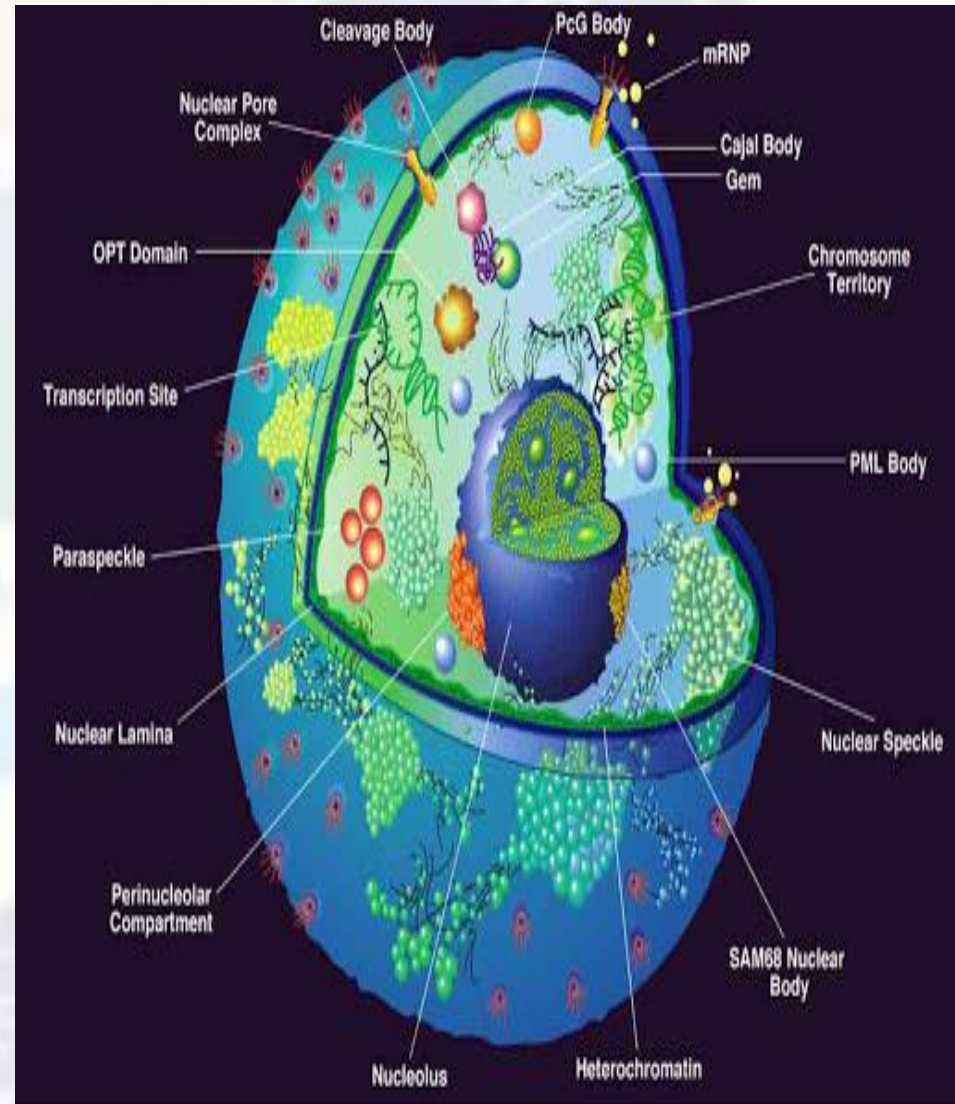
□ Nucleus

- ❖ The nucleus is well defined, centrally located and spherical cellular component which regulate all the vigorous process of the cell. Nucleus constituted by the three structures :
 - **Nuclear membrane:** Nuclear membrane is the outer most layer of the nucleus and occurs in both plant and animal cells.
- ❖ The nuclear membrane is made by the two layer of lipoprotein.
- ❖ It forms an envelope like structure around the nucleus known as nuclear envelop.
- ❖ The nuclear envelop contain many tiny pore which regulate the movement of the chemical substance. The outer nuclear membrane of nucleus remains continues with the membrane of endoplasmic reticulum and plasma membrane.
- **Nucleoplasm and chromosomes:** Like the cytoplasm, the nucleus contains a watery substance called nucleoplasm or karyoplasm.
- ❖ The space between the nuclear membrane and nucleolus is filled by nucleoplasm.
- ❖ It contains dissolved phosphorus, ribos sugar, proteins, nucleotides and nucleic acids.
- ❖ The nucleoplasm contains some threads like structure called the chromosomes. The chromosomes appear only during the cell division otherwise they occur in the form of chromatin granules.
- **Nucleolus:** The nucleoplasm contains a conspicuous darkly stained spherical body known as the nucleolus.

- ❖ Chemically nucleolus is composed of large amount of ribosomal protein and ribosomal RNA.
- ❖ The nucleolus stores the rRNA molecules which are synthesized by nucleolar organizer region of DNA and provides the raw material such as different kind of rRNA's and ribosomal proteins for the biogenesis of ribosomes.

❖ Functions

- ✓ Controls heredity characters
- ✓ Control the synthesis of particular enzymes.
- ✓ It is responsible for protein synthesis, cell division, growth and differentiation.
- ✓ Stores heredity material in the form of deoxy-ribonucleic acid (DNA) strands. Also stores proteins and ribonucleic acid (RNA) in the nucleolus.
- ✓ It is a site for transcription process in which mRNA are produced for protein synthesis.
- ✓ It helps in exchange of DNA and RNA (heredity materials) between the nucleus and the rest of the cell.
- ✓ Nucleolus produces ribosomes and are known as protein factories.
- ✓ Regulates the integrity of genes and gene expression.



KEY POINTS OF THE LECTURE

- ❑ The cell is a unit of biological activity delimited by a semipermeable membrane and capable of self-reproduction in a medium free of other living systems.
- ❑ Cells emerged on the Earth at least 3.5 billion years ago.
- ❑ The properties of cell are; highly complex and organized, possess a genetic program, evolve, respond to stimuli, carry out chemical reactions, reproduce themselves, acquire and utilize energy, capable of self regulation, carry out mechanical activities
- ❑ The cell theory states that all organisms are composed of one or more cells. That cells are the fundamental unit of structure and function in all living organisms, and that all cells come from pre-existing cells.
- ❑ Collectively, all the living cells are broadly classified into two category i.e., prokaryotic cells and eukaryotic cells, according to whether their genetic materials are enclosed by a nucleus envelope or not.
- ❑ The shape may be vary with animal to animal or organ to organ. Even the cells of the same organ may display variations in the shapes.
- ❑ Typically the animal cell is spherical in shape but irregular, cylindrical, cuboidal, triangular, tubular, polygonal, oval, round elongated etc have also been seen in different organisms. Some cells (*Amaeba* and leucocytes) able to change their body shape very frequently

KEY POINTS OF THE LECTURE

- ❑ Generally, the eukaryotic cells are microscopic in nature but some animals and plant cells are easily visible by the naked eyes. For example: the egg of ostrich is the largest cell in the diameter, some nerve cells are considered more than 3-5 feet in length. Usually, the size of cells may vary between $1\mu\text{m}$ to $175000\mu\text{m}$ (175 mm).
- ❑ The numbers of the cells in particular organisms are depending upon the size of the organisms. Larger size have the great number of the cells in their body.
- ❑ The animal and plant cell are different from each other.
- ❑ The plant cell possess cell walls containing cellulose, hemicelluloses and pectin, a large vacuole that regulates turgor pressure allows plants to grow tall, while animal cell do not..
- ❑ The plant cells are well defined cell. Therefore, we can categorize the cell into; Cell wall and plasma membrane, Cytoplasm and Nucleus
- ❑ The cell provide the structure and protection to the cell.
- ❑ The plasma it is selectively permeable to ions and organic molecules thus regulate the movement of substances in the cells.
- ❑ The cytoplasm conduct various vital activities of life.

KEY POINTS OF THE LECTURE

- ❑ The microtubules provide help and support and transportation to the cell.
- ❑ Plastids are the characteristic feature of the plant cell. They function specially for the storage of starch, lipids and proteins, therefore, they are called amyloplasts, lipoplasts and proteinoplasts, respectively.
- ❑ The green coloured plastid is known as chloroplasts which help in the biosynthesis of food by the process of photosynthesis.
- ❑ Mitochondria called the power house of the cell which provide the energy to conduct the various vital activities of the cell.
- ❑ Endoplasmic reticulum provides mechanical support to the cell and sites for a number of enzymes and cytochromes to carry out specific reactions.
- ❑ Golgi complex is to carry out the processing of proteins generated in endoplasmic reticulum and also transports protein to the different parts of cell.
- ❑ Cytoplasmic vacuole is also the characteristic feature of the plant cell. Vacuoles are important in autophagy, store and help digest food, contain water, phenol, flavonols, anthocyanins, alkaloids, and stored product such as sugar and proteins.
- ❑ Ribosomes are the site of protein synthesis.
- ❑ Nucleus controls all the functions of the cell. It regulates the hereditary characters, synthesis of particular enzymes, responsible for protein synthesis, cell division, growth and differentiation.

TERMINOLOGY OF CELL

- ❑ **ATP:** Adenosine triphosphate. An adenine molecule, or a nucleotide, attached to three linearly connected phosphate groups ($-H_2PO_4R$, where R is a functional group). ATP basically shuffles energy around to support metabolism and a bunch of super important cellular processes, like photosynthesis.
- ❑ **Cell Membrane:** A thin semi-permeable membrane that surrounds the cytoplasm of a cell.
- ❑ **Cell theory:** The scientifically supported idea that the basic structural unit of life is the cell and that all cells arise from other cells.
- ❑ **Cell wall:** A rigid, but often flexible, layer containing cellulose or chitin, pectin, and other polymers. The cell wall is the outermost structure of plant, algal, fungal, and some prokaryotic cells.
- ❑ **Centriole:** A tubular structure that is made of protein and found only in animal cells. It is involved in cell division and the formation of flagella and cilia.
- ❑ **Chloroplast:** The organelle (see definition; think "mini organ") in plant cells, and a few other eukaryotic cells, that contains chlorophyll, the magical green pigment, and carries out the process of photosynthesis.
- ❑ **Chromatin:** The mass of genetic material composed of DNA and proteins that condense to form chromosomes during eukaryotic cell division.
- ❑ **Chromosome:** A long, stringy aggregate of genes that carries heredity information (DNA) and is formed from condensed chromatin.
- ❑ **Cilia and Flagella:** A protrusions from some cells that aid in cellular locomotion.

TERMINOLOGY OF CELL

- ❑ **Cytoplasm:** All of the contents outside of the nucleus and enclosed within the cell membrane of a cell.
 - ❑ **Cytoplasm:** The cytosol (fluid inside cells), organelles (except the nucleus), and other particles enclosed within the cell membrane. The cytoplasm is the site of most cellular activities, including glycolysis, production of energy from carbohydrates, and cell division, or the way cells reproduce.
 - ❑ **Cytoskeleton:** A network of fibers throughout the cell's cytoplasm that helps the cell maintain its shape and gives support to the cell.
 - ❑ **Cytosol:** The fluid component of the cytoplasm (collective name for the stuff within the boundaries of the cell membrane) composed of cytoskeleton filaments, dissolved molecules, and water. The cytosol is the part of the cytoplasm between the cell membrane and organelle membranes.
 - ❑ **DNA:** Deoxyribonucleic acid. DNA is a macromolecule ("macro" = big) also known as a nucleic acid that is composed of phosphate groups, deoxyribose sugar groups, and the nucleotides adenine, guanine, cytosine, and thymine. DNA contains the genetic code needed by all cells to produce proteins and other molecules necessary to sustain life. He seems to make into every one of Shmoop's Biology glossaries.
 - ❑ **Endoplasmic Reticulum:** A network of tubules and flattened sacs that serve a variety of functions in the cell.
 - ❑ **Enzymes:** A protein that catalyzes, or increases the rate of, a chemical reaction in a cell.
- Eukaryote: An organism whose cells contain a membrane-bound nucleus.

TERMINOLOGY OF CELL

- ❑ **Flagellum:** A protrusion of the cell membrane in some eukaryotic and prokaryotic cells that spins or lashes back and forth to aid in cellular locomotion.
- ❑ **Genes:** Segments of DNA located on chromosomes that exist in alternative forms called alleles.
- ❑ **Genome:** All of an organism's heredity information encoded in either DNA or RNA.
- ❑ **Golgi body:** An organelle in eukaryotic cells containing between three and seven flattened membrane disks called cisternae. The Golgi body packages and processes proteins and lipids, and is also called the "Golgi apparatus."
- ❑ **Histone:** Large protein complexes that control the messages sent from the DNA to the rest of the cell.
- ❑ **Lysosome:** A spherical, membrane-bound organelle in eukaryotic cells that contains enzymes (catalysts) and other proteins that digest, or break down, substances that have been taken into a cell by phagocytosis.
- ❑ **Meiosis:** A two-part cell division process in organisms that sexually reproduce, resulting in gametes with one-half the number of chromosomes of the parent cell.
- ❑ **Microtubules:** Fibrous, hollow rods that function primarily to help support and shape the cell.
- ❑ **Mitochondrion (plural *mitochondria*):** A membrane-bound organelle that provide the usable energy (in the form of ATP) from lipids, sugars, and proteins in a process known as cellular respiration. The mitochondrion is the cell's powerhouse.

TERMINOLOGY OF CELL

- ❑ **Mitosis:** A phase of the cell cycle that involves the separation of nuclear chromosomes followed by cytokinesis.
- ❑ **Nucleus:** A membrane-bound structure that contains the cell's hereditary information and controls the cell's growth and reproduction.
- ❑ **Organelles:** Tiny cellular structures, that carry out specific functions necessary for normal cellular operation. E.g., Golgi bodies, lysosomes, mitochondria, chloroplasts, endoplasmic reticulum, vacuoles, and vesicles
- ❑ **Plant Cells:** Eukaryotic cells that contain various membrane-bound organelles. They are distinct from animal cells, containing various structures not found in animal cells.
- ❑ **Plasma membrane:** A phospholipid (see previous definition) bilayer separating the interior of a cell from the surrounding environment. The membrane does lots of stuff, including protecting the cell, transporting materials into and out of the cell, and helping the cell communicate to other cells.
- ❑ **Polar Fibers:** Spindle fibers that extend from the two poles of a dividing cell.
- ❑ **Prokaryote:** An organism whose cells lack nuclei and membrane-bound organelles. Prokaryotes are generally single-celled.
- ❑ **Prokaryotes:** Single-celled organisms that are the earliest and most primitive forms of life on earth.
- ❑ **Protein:** A chain, or chains, of amino acids specifically folded to take on a certain shape, one that determines the protein's function.

TERMINOLOGY OF CELL

- ❑ **Ribosome:** A complex structure made of proteins and ribosomal RNA, or rRNA. Ribosomes are found in all cells, both prokaryotic and eukaryotic. Together with messenger RNA (mRNA) and transfer RNA (tRNA), ribosomes synthesize proteins from amino acids (the building blocks of proteins). Ribosomes are not generally considered organelles because they are not membrane-bound.
- ❑ **RNA:** Ribonucleic acid. RNA is a macromolecule composed of phosphate groups (aka $\text{H}_2\text{PO}_4\text{R}$, where R is a functional group), ribose sugars, and the nucleotides adenine, guanine, cytosine, and uracil.
- ❑ **Rough endoplasmic reticulum (RER):** A highly membranous organelle in eukaryotic cells, with a membrane-bound nucleus, dotted with ribosomes. The dots inspired the "rough" part of the name. The RER is the major site of protein synthesis.
- ❑ **Smooth endoplasmic reticulum (SER):** A highly membranous organelle in eukaryotic cells that is not associated with ribosomes. The SER is the major site of lipid and steroid synthesis, and is continuous with the nuclear membrane and rough endoplasmic reticulum, or RER.
- ❑ **Vacuole:** A large, membrane-bound organelle found in most plant and fungal cells, as well as some animal and bacterial cells. The vacuole's job varies with cell type, but in many cases, the vacuole is involved in water regulation, waste removal, and pH balance within the cell.
- ❑ **Vesicle:** A small, sac-like organelle involved in the transport and storage of cellular substances, especially proteins marked for secretion from the cell.

SOME QUESTIONS RELATED TO THE LECTURE

- ❑ **Question 1:** What is cell? Explain the properties of cell.
- ❑ **Question 2:** Write a detail note on Types of cell.
- ❑ **Question 3:** Explain the Differences between prokaryotic and eukaryotic cell.
- ❑ **Question 4:** Listed the differences between plant and animal cell.
- ❑ **Question 5:** Illustrate and explain an example of prokaryotic cell .
- ❑ **Question 6:** What do you understand by eukaryotic cell.
- ❑ **Question 7:** Explain the main characteristics of plant cell.
- ❑ **Question 8:** Define the functions of various cell organelles in plants.
- ❑ **Question 9:** Define the ultrastructre of nucleus and its function in plant cell.
- ❑ **Question 10:** Define the cytoplasm in cell.
- ❑ **Question 11:** Explain the structure of cell wall and its functions in plant kingdom.

BIBLIOGRAPHY

- ❑ Bianconi, Eva; Piovesan, Allison; Facchin, Federica; Beraudi, Alina; Casadei, Raffaella; Frabetti, Flavia; Vitale, Lorenza; Pelleri, Maria Chiara; Tassani, Simone (November 2013). "An estimation of the number of cells in the human body". *Annals of Human Biology*. 40 (6): 463–471. [doi:10.3109/03014460.2013.807878](https://doi.org/10.3109/03014460.2013.807878). ISSN 0301-4460.
- ❑ Campbell NA, Williamson B, Heyden RJ (2006). *Biology: Exploring Life*. Boston, Massachusetts: Pearson Prentice Hall. ISBN 978-0-13-250882-7.
- ❑ <https://biologydictionary.net/plant-cell/>
- ❑ <https://courses.lumenlearning.com/boundless-biology/chapter/themes-and-concepts-of-biology/>
- ❑ [https://en.wikipedia.org/wiki/Cell_\(biology\)](https://en.wikipedia.org/wiki/Cell_(biology))
- ❑ <https://www.thoughtco.com/cell-biology-glossary-373293>
- ❑ <https://ghr.nlm.nih.gov/primer/basics/cell>
- ❑ <https://sciencing.com/main-function-microtubules-cell-8552402.html>
- ❑ <https://www.biologyexams4u.com/2014/02/functions-of-endoplasmic-reticulum-er.html#.XrUENiBEnIU>
- ❑ <https://www.britannica.com/science/cell-biology>
- ❑ Koch AL (2003) Bacterial wall as target for attack: past, present, and future research. *Clinical Microbiology Reviews*. 16 (4): 673–87.
- ❑ Neil A C, Williamson B, Heyden RJ (2006) *Biology: Exploring Life*. Boston, Massachusetts: Pearson Prentice Hall. ISBN 9780132508827.
- ❑ Whitman WB, Coleman DC, Wiebe WJ (1998) Prokaryotes: The unseen majority. *Proceedings of the National Academy of Sciences of the United States of America*. 95 (12): 6578–6583.

श्रद्धावाँल्लभते ज्ञानं

