Plant cell structure: -

All organisms are composed of cells.

Cells are the basic units of the structural and functional unit of all living organisms

The study of cells by microscope is known as **Cytology**. The study of cell structure and function is called **Cell biology**.

The size and shape of plant cells are:

1- Cell shape: * cubical * prismatic * tubular * cylindrical * spherical * oval * polyhedral
2- Cell size: 10-100 microns average except latex cell is 5 meters.

Plant cell components:

A- Cytoplasmic components (Living components).

B-Non-cytoplasmic components (Non-living components or ergastic substances).

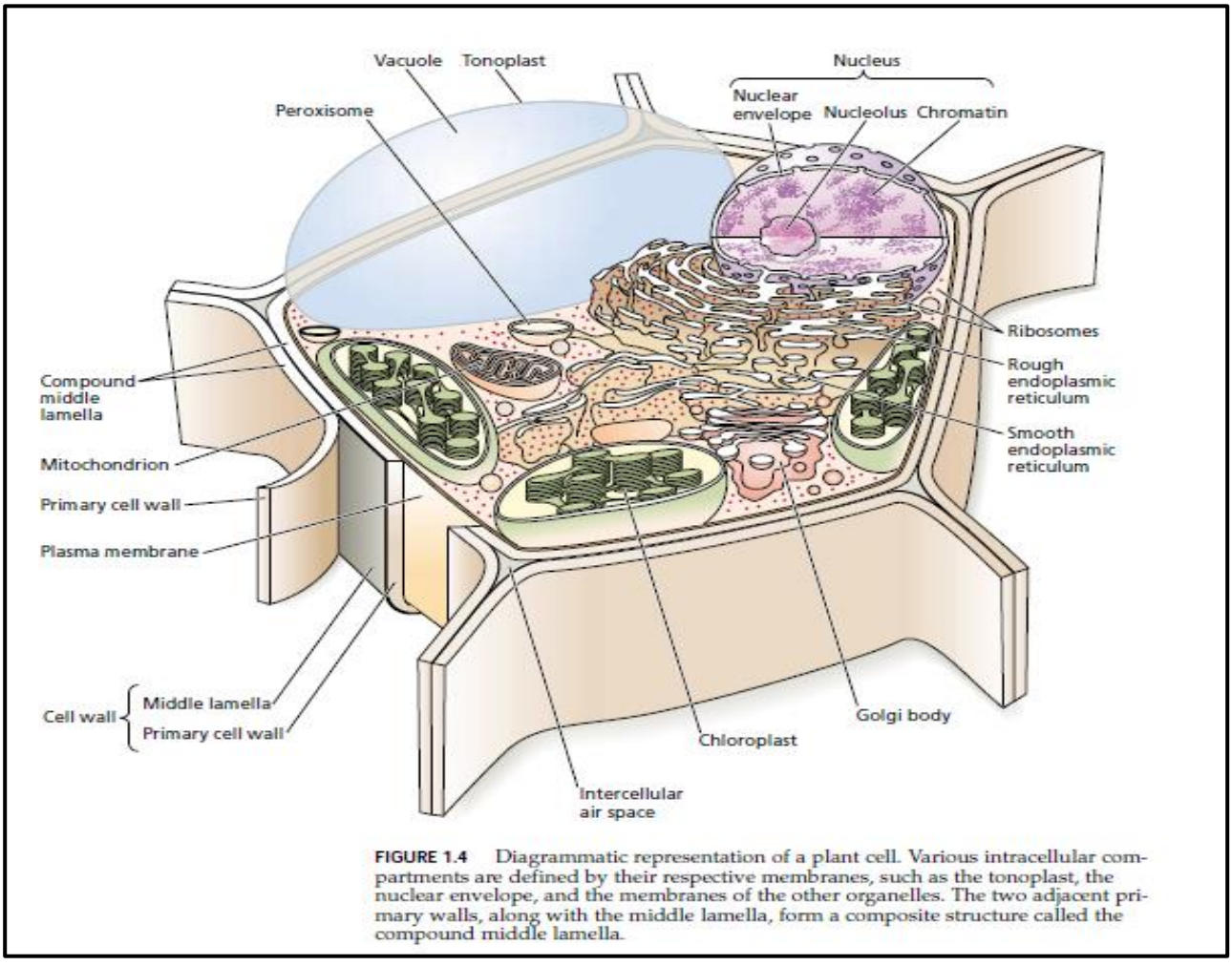

FIGURE 1.4 Diagrammatic representation of a plant cell. Various intracellular compartments are defined by their respective membranes, such as the tonoplast, the nuclear envelope, and the membranes of the other organelles. The two adjacent primary walls, along with the middle lamella, form a composite structure called the compound middle lamella.

▪The basic components of a cell are cell membrane, cytoplasm and nucleus. The cytoplasm and nucleus are enclosed within the cell membrane, also called the plasma membrane. The membrane separates cells from one another and also the cell from the surrounding medium. The plasma membrane is porous and allows the movement of substances or materials both inward and outward.

▪The central dense round body in the centre is called the nucleus. The jelly-like substance between the nucleus and the cell membrane is called cytoplasm. The cytoplasm is the relatively liquid matrix of the protoplast, often referred to as the **hyaloplasm**. Its viscosity may vary in different regions of the cell, Various other components, or organelles, of cells are present in the cytoplasm. These are mitochondria, Golgi bodies, ribosomes, etc.

A- Cytoplasmic components (Living components):

1-Cell membrane or Plasma membrane:

▪It is also called plasmalemma sometimes also called the ectoplast. It is the living outer boundary of all cells. It is mainly lipoproteinaceous (made of lipids and proteins). A semipermeable membrane encloses the cytoplasm within a cell. It is composed of variable amounts of fat type molecules (lipids) and proteins, and has within it channels for the movement of ions such as potassium (K^+), calcium (Ca^{2+}), and hydrogen (H^+).

▪The **fluid mosaic model** characterizes the plasma membrane and other cell membranes as consisting of a double layer, or bilayer, of lipid molecules in which **proteins** are embedded. The ratio of proteins to lipids is 3:2. Some of the proteins extend through the lipid layer, each end of a molecule projecting out opposite sides. Others remain on or partially embedded in one or the other surface.

▪A number of proteins are embedded in the lipid bilayer in a way that resembles a ***mosaic pattern.***

▪The **plasma membrane** is a single membrane bounding the cytoplasm. New material is added to it and old material removed by vesicles. The plasma membrane has a number of functions:

(i) maintaining ionic homeostasis of the cytoplasm and transporting nutrients and other products.

(ii) sensing and signaling the cells environment. **Receptor proteins** at the plasma membrane respond to the presence of signals (e.g. hormones) and cause changes in intracellular signaling molecules which result in altered cell functions;

(iii) **secreting materials** (e.g. the constituents of the cell wall.

(iv) **regulating turgidity** by osmotic effects resulting in the cytoplasm exerting force against the cell wall.

(v) **communicating** with other adjacent cells through **plasmodesmata.**

Plasmodesmata, strands of cytoplasm that protrude through pores in the cell walls and connect the protoplasts of adjacent cells; these are avenues of material transport in plants.

▪Most membranes are **selectively (differentially) permeable,** permitting or preventing materials from leaving or entering the cell. When toxic substances destroy the selective permeability and the membrane becomes **freely permeable,** materials leak unchecked in and out, resulting in death of the cell.

▪Plant cell organelles:

2- **Nucleus:**

The science related to the study of nucleus is called Karyology. Nucleus is a master organelle which acts as the controlling centre of the cell. All the vital activities of the cells are controlled by the nucleus. It is the carrier of parental characters to offspring. It is the store house of hereditary information.

It is an important component of the living cell. It is generally spherical and located in the centre of the cell. It can be stained and seen easily with the help of a microscope. Nucleus is separated from the cytoplasm by a double membrane called the **nuclear membrane (envelope)** with a ***perinuclear space*** between them. In various places the outer membrane of the envelope is continuous with the endoplasmic reticulum, so that the perinuclear space is continuous with the lumen of the endoplasmic reticulum. This membrane is also porous and allows the movement of materials between the cytoplasm and the inside of the nucleus. With a microscope of higher magnification, we can see a smaller spherical body in the nucleus. It is called the **nucleolus**. In addition, nucleus contains thread-like structures called **chromosomes.** These carry genes and help in inheritance or transfer of

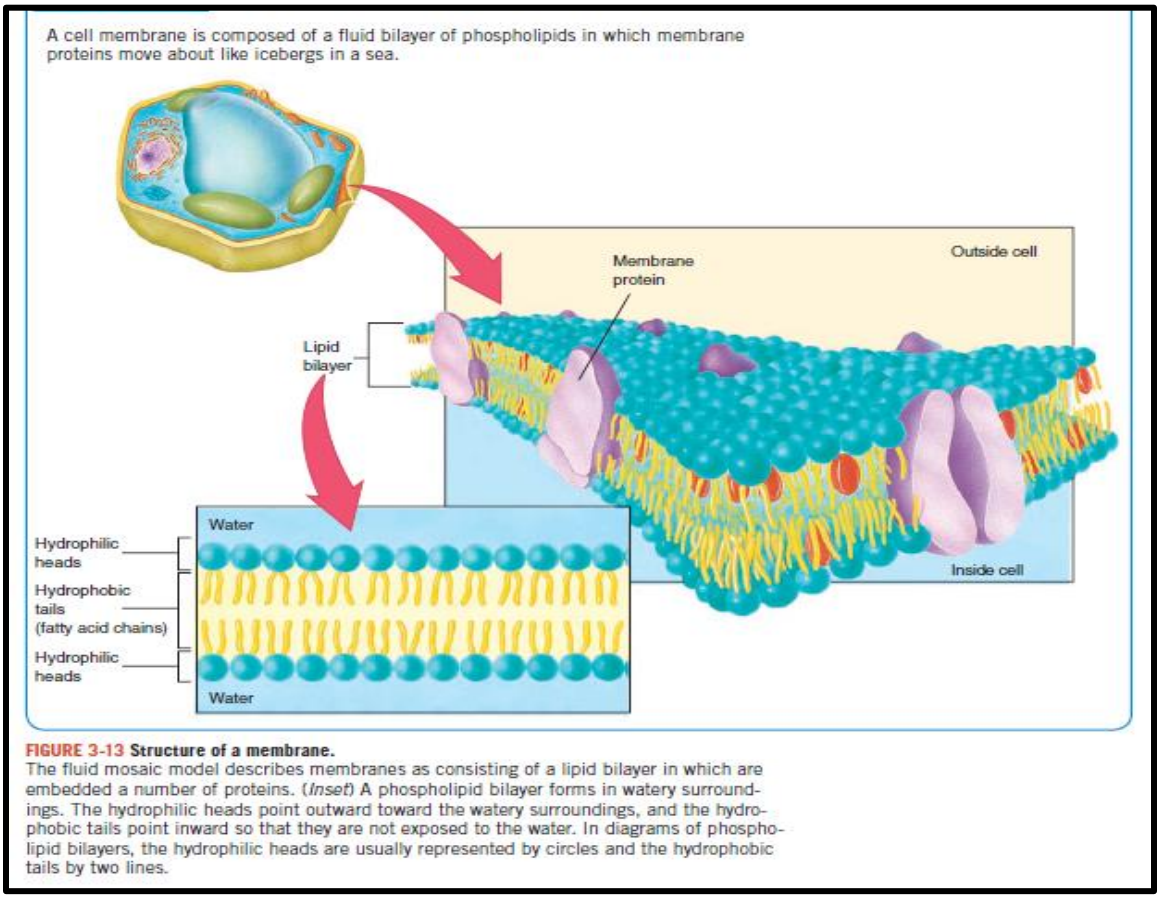

FIGURE 3-13 Structure of a membrane.
The fluid mosaic model describes membranes as consisting of a lipid bilayer in which are embedded a number of proteins. (*Inset*) A phospholipid bilayer forms in watery surroundings. The hydrophilic heads point outward toward the watery surroundings, and the hydrophobic tails point inward so that they are not exposed to the water. In diagrams of phospholipid bilayers, the hydrophilic heads are usually represented by circles and the hydrophobic tails by two lines.

characters from the parents to the offspring. The chromosomes can be seen only when the cell divides.

▪ Normally, there is a single nucleus per cell. Exceptionally, phloem sieve tube elements and dead cells, like fibres, vessels, tracheids and cork cells are devoid of nucleus.

▪Other important nuclear structures, which are not apparent with light microscopy unless the cell is stained or is in the process of dividing, include thin strands of **chromatin.** When a nucleus divides, the chromatin strands coil, becoming shorter and thicker, and in their condensed condition, they are called **chromosomes.** Chromatin is composed of protein**(histones)** and DNA .

3-Plastids: - are characteristic of plant cells and otherwise only occur in plant-like protists. They are organelles bounded by a double membrane. There are several types of plastid in plant cells. **Chloroplasts** are photosynthetic plastids found in the mesophyll cells of leaves, the cortex of herbaceous stems and in small numbers elsewhere in the plant. The green coloration is due to the presence of the pigment chlorophyll. Which have been classified as follows, on basis of their colour.

1-Leucoplast: Colourless, which do not get sunlight store reserve food material, occur in the cells of seeds, underground stems, roots, tubers, rhizomes. Leucoplasts are of three types.

(**i) Amyloplast:** These synthesise and store starch grains, found in potato tubers, wheat and rice grains.

(ii) Elaioplast: These store fats (lipids, oils), mostly found in oily seeds. Fats and oils store large amounts of energy.

(iii) Aleuronoplast: Store proteins, found in grains.

2-**Chromoplasts: -** contain pigments other than chlorophyll (red, yellow, orange, etc) and are associated with brightly colored structures like ripe fruit, and petals of flowers.

3- Chloroplast: Chloroplasts are green plastids. These plastids contain green pigment, chlorophyll and take part in photosynthesis. Their number, size and shape vary. Each chloroplast has two-unit membranes, thus it is a double-membraned organelle. In higher plants, the chloroplasts are usually biconvex (lens shaped). the interior of a chloroplast contains thylakoids, membranous stacks of thin, flat, circular plates; a stack of **thylakoids** is called a **granum** (pl., *grana*). The grana are embedded in a jellylike fluid, the **stroma,** which contains enzymes that catalyze the chemical reactions of photosynthesis that convert carbon dioxide to carbohydrate. Each chloroplast also contains a small amount of DNA and a few ribosomes. The presence of DNA and ribosomes in chloroplasts is significant because it indicates that they had free-living ancestors.

4-Mitochondria:.

The powerhouses of eukaryotic cells are the **mitochondria** (sing., *mitochondrion*), tiny organelles **Mitochondria** are sites of respiration **(site of Krebs – cycle**) and synthesis **(energy product)** of adenosine triphosphate (ATP) which supplies the energy required

for the numerous metabolic activities of the cell. Mitochondria, usually less than 1.0µm in diameter and no more than 5.0 µm long, a series of chemical reactions in which fuel molecules are broken down into carbon dioxide and water with the release of energy, occurs in mitochondria.

Mitochondria vary in shape commonly appear as rod-shaped, but may be spherical, dumbbell shaped or sometimes branched; and they may vary from one form to another. They are too small to be seen under a light microscope. Their internal structure is complex. Each mitochondrion is bounded by a double membrane. The inner membrane, because it has a larger surface area than the outer membrane, folds inward, each -the folds, called **cristae,** projecting into the interior membrane of the mitochondrion. Some of the enzymes for cellular respiration are arranged along the cristae; other respiratory enzymes are found in the **matrix,** the fluid inside the inner mitochondrial membrane. Each mitochondrion also contains a small amount of DNA and a few ribosomes.

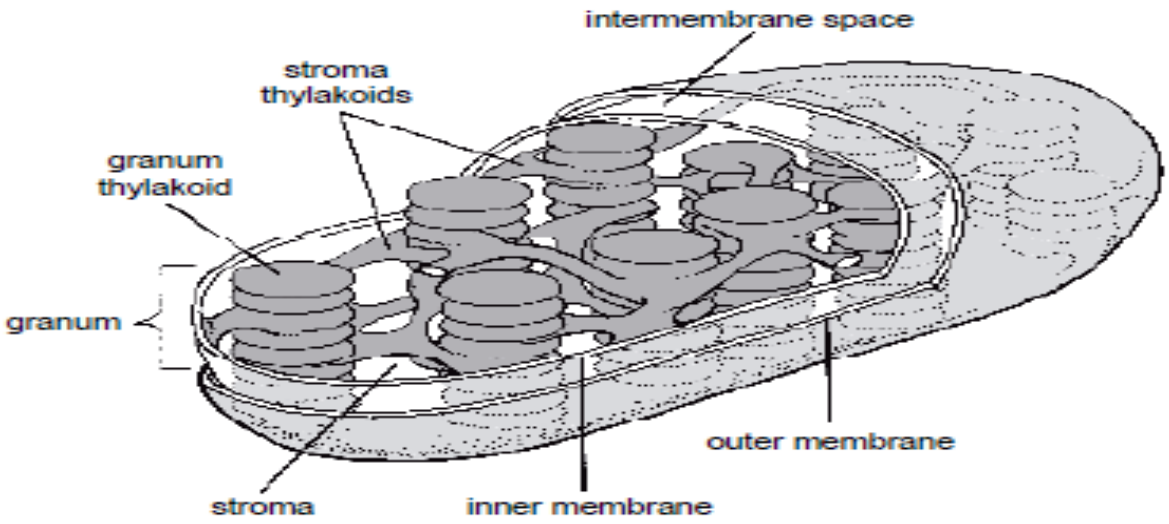

FIGURE 2.8

Three-dimensional structure of a chloroplast. Note that the internal membranes (thylakoids) are not connected with the plastid envelope. (From Raven et al., 1992.)

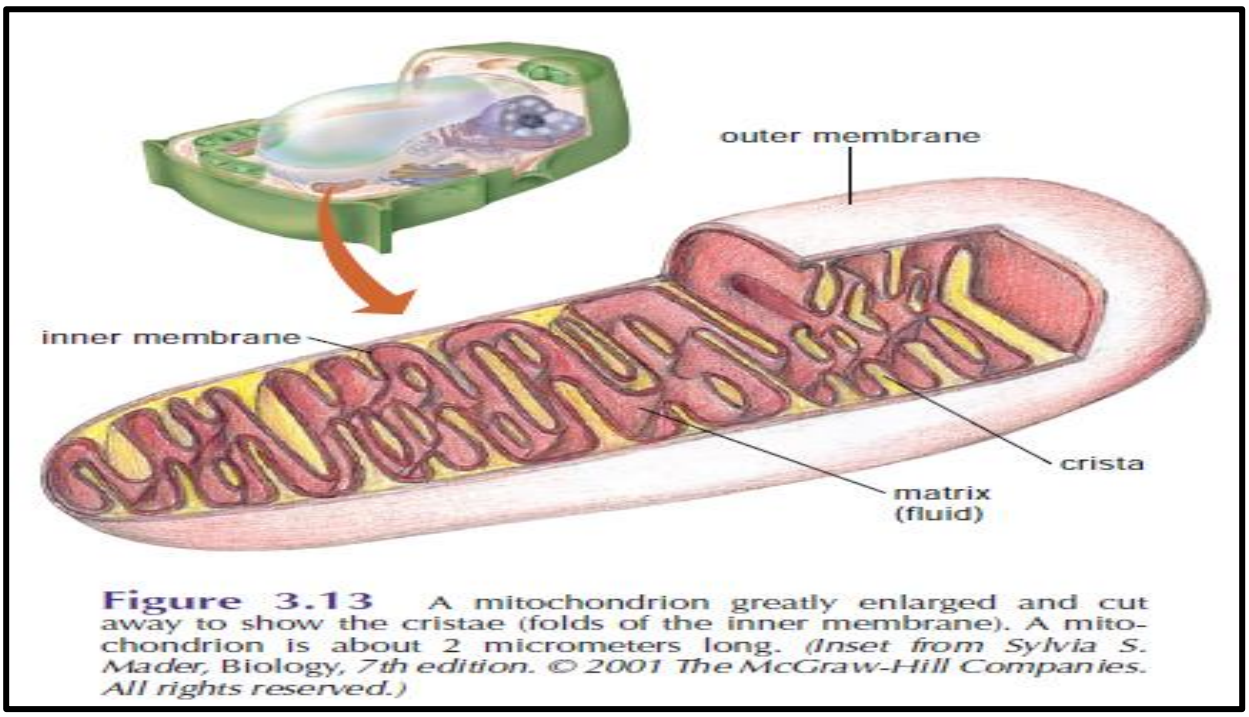

Figure 3.13 A mitochondrion greatly enlarged and cut away to show the cristae (folds of the inner membrane). A mitochondrion is about 2 micrometers long. *(Inset from Sylvia S. Mader,* Biology, *7th edition. © 2001 The McGraw-Hill Companies. All rights reserved.)*

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Golgi complex: (Golgi apparatus or Dictyosomes):

- Helps in excretion of waste product.
- Helps in formation of cell plate at the time of cell division.
- Golgi bodies play important roles in the development of the middle lamella as well the plasma membranes and cell walls of contiguous cells. During cell wall formation, precursor compounds of cell wall components are transferred in Golgi vesicles to the sites of wall synthesis.

It is found in all eukaryotic cells (except RBC, antherozoids of bryophytes and pteridophytes and sieve tubes of higher plants). It is absent in prokaryotes. Golgi complex is derived from ER. It is made up of a stack of flat sac-like, disc-shaped structures called cisternae surrounded by vesicles and tubular structures. Each set of cisternae is arranged like stack of plates, called a dictyosome. that the group of cisternae is dictyosome and many dictyosomes interconnected with tubules are called Golgi apparatus.

6-Endoplasmic reticulum: - **(The** endoplasmic reticulum (ER) is a system of flattened sacs or tubes of membrane.)

The **endoplasmic reticulum** (ER) is a network of membranes in the cytoplasm that form either tubules (**tubular ER**) or flattened sacs (**cisternal ER**). The ER may be divided into two types. Smooth ER is the site of lipid synthesis and rough ER is site of protein synthesis **Rough ER** appears rough due to the presence of **ribosomes**. ER may be associated with the nuclear envelope.

7- Ribosomes:

Ribosomes are found in both, prokaryotic as well as eukaryotic cells. They are smallest, most abundant, non-membranous organelles. Ribosomes are made up of ribosomal-proteins bound with rRNA molecules. Hence, these are also called as ribo nucleo protein particles. Dissociation of proteins from ribosomes may be facilitated by 4 M urea and 2 M lithium chloride. In prokaryotes, ribosomes float freely in the cytoplasm; but in eukaryotes, they remain free as well as bound with ER and nuclear envelope. These are also found inside organelles, like nucleus, plastids and mitochondria, of eukaryotic cells and are called organeller ribosomes. Each ribosome consists of two subunits, a smaller and a bigger subunit.

8- cytoskeleton: - (is composed of protein fibers) The **cytoskeleton** is involved in movement within a cell and in a cell's architecture.

The **cytoskeleton** is a network of fibers that extends throughout the cytoplasm and provides structure to a eukaryotic cell. The cytoskeleton, which is also important in cell movement, includes two types of fibers, microtubules and microfilaments.

Microtubules are involved in the addition of cellulose to the cell wall. Microtubules also make up the spindle, a special structure that moves chromosomes during cell division. Other microtubules are a part of flagella and cilia, hair like extensions of certain cells that aid in locomotion.

Microfilaments, which are much thinner than microtubules, can contract and are responsible for **cytoplasmic streaming,** the movement of cytoplasm within the cell. Cytoplasmic streaming has a variety of purposes.

9- Microbodies: - (Play Specialized Metabolic Roles in Leaves and Seeds)

Various small bodies distributed throughout the cytoplasm tend to give it a granular appearance. Examples of such components include types of small, spherical organelles called **microbodies,** which contain specialized enzymes and are bounded by a single membrane. The two main types of microbodies are **peroxisomes and glyoxysomes**. **Peroxisomes** are found in all eukaryotic organisms, and in plants they are present in photosynthetic cells. Peroxisomes function both in the removal of hydrogens from organic substrates, consuming O_2 in the process, While the **glyoxysome**, is present in oil-storing seeds. Glyoxysomes contain the *glyoxylate cycle* enzymes, which help convert stored fatty acids into sugars that can be translocated throughout the young plant to provide energy for growth.

10- Sphaerosomes:

These are very small, spherical organelles with single unit membrane (0.5 – 2.5 μm). Sphaerosomes contains enzymes for the synthesis of oils and fats and have high lipid contents. Sphaerosomes are found in endosperm and cotyledons, fat-storing structures. Their main functions are collection, translocation and synthesis of fatty substances.

2- Non – cytoplasmic components or Non – livings components or non – protoplasmic components: which includes
1- Vacuoles 2- Cell wall 3- Ergastic substances.

Vacuoles:
In a mature living plant cell, as much as 90% or more of the volume may be taken up by one or two large central **vacuoles** that are bounded by **vacuolar membranes (tonoplasts)** . The vacuolar membranes, which constitute the inner boundaries of the living part of the cell, are similar in structure and function to plasma membranes. A **vacuole** is a membrane-bounded sac filled with a liquid that contains a variety of materials in addition to water—dissolved salts, ions, pigments, and waste products. Vacuoles are present in many types of cells but are most common in plant cells and the cells of certain protists.
The vacuole performs several important functions for a plant cell. **(1)** One of the most significant is that the vacuole helps the cell maintain its shape by making it turgid**. (2)** The vacuole also serves as a temporary storage area; excess materials such as calcium ions are stored in the vacuole until the cell needs additional calcium. Water soluble pigments such as *anthocyanins,* which are blue, purple, or red, are often stored in the vacuole. For example, anthocyanin is stored in the vacuoles of red onion cells, giving them their characteristic color.

Cell wall:
The cell wall encloses and protects the cell contents and plays a vital role in cell division and cell expansion. Composed of cellulose compounds, hemi cellulose, lignin, suberin, cutin, pectic and fats. Cell wall provides mechanical strength and acts as exoskeleton of the cell. It provides a definite shape to the plant cell. Cell wall has minute pits or pores through which the protoplasmic strands pass from one cell to another. These protoplasmic strands are called plasmodesmata. Cell wall is composed of the following layers:

1- Primary cell wall
It is the outer most layer of cell wall, secreted on both the sides of middle lamella. It is thin, elastic, first formed wall layer, mostly composed of cellulose microfibrils and pectin. Lignin is absent in primary wall. Primary wall is made of microfibrils of cellulose. The microfbrils are the basic structural units of cell wall. Hemicelluloses are matrix polysaccharides that bind to cellulose.

2- Middle lamella

3- Secondary cell wall. It is secreted on the inner surface of primary wall and lies near the plasma membrane. It is mostly composed of cellulose, hemicellulose and lignin. It provides mechanical strength to the plant.

The function of the cell wall is the following:
1- It provides a mechanical support and gives a definite shape and protection to the cell.

2- It is capable to inhibited water and thus helps in the movement of water and solutes towards protoplasm.

Major ergastic substances of plants:

A number of metabolically inactive cell inclusions also remain suspended in cytoplasmic matrix which are called ergastic substances. These are reserve materials, secretory products, resins, gums, essential oils, etc. These substances are the product of primary as well as secondary metabolic activities. These substances are broadly grouped into three types.

A) Reserve materials:
Include carbohydrates, fats and oils and proteins. These are also used as food in energy-generating reactions.

B) Secretory substances:
A variety of substances which are not used as food. Found in special types of glands / structures. Main secretory products of plants are as follows:

Pigments:
Chlorophylls, carotenes and xanthophylls, etc. Anthocyanins (blue, purple, pink) are found in vacuolar sap of petals of flowers, fruits and young leaves, giving them different colours.

Enzymes:
Proteinaceous in nature. They are involved in different metabolic reactions.

Nectaries:
It is a sweet substance (mixture of sucrose, glucose and fructose) secreted in nectar glands or in other parts of the flowers. They attract insects for pollination.

Certain mineral crystals which are found in plants:

Raphides:
Needle-like crystals made of calcium oxalate, found in storage tissues like pith, cortex, etc. Cells containing these are called idioblasts they occur commonly in monocots. Found in *Pistia, Eichornia, Colocasia and Balsam* plant.

Sphaeraphides or Druses:

Star-shaped or spherical, calcium oxalate crystals. Found *in Dioscorea, Pistia, Nerium leaves, Papaya, etc.*

Cystolith $CaCO_3$ Crystal:
Found in cellulose walls, appear like a bunch of grapes. Found in *Banyan* leaves *(Ficus),* worm-like crystals in *Justicia* leaves.

The difference between plant cells and animal cells:
1- Plant cells have rigid walls, while animals cells are bounded by a flexible membrane.

2- Plants are not activity motile, but most animals are mobile.

3- Only plants contain chlorophyll and perform photosynthesis.

4- Plant store their food reserves as starch, but animals have glycogen and fat as their principle food reserves.