**Cell Theory**

In 1838, a German botanist **Mathias Jacob Schleiden** (1804 – 1881) put forth the idea that cells

were the units of structure in the plants. Along with a coworker, a German zoologist, **Theodor**

**Schwann** (1810 -1882) applied Schleiden’s thesis to the animals.

(i) All living things are composed of one or more cells and products or secretions of the cell.

(ii) All metabolic reactions in unicellular and multicellular organisms take place in cells.

(iii) All cells come from the division of pre-existing cells.

(iv)The cell is the basic unit of structure and function of all life.

**Exception to cell theory**

Some certain organisms do not have true cells; all true cells share the following three basic characteristics:

1. A set of genes which constitute the blueprints for regulating cellular activities and making new cells.
2. A limiting plasma membrane that permits controlled exchange of matter and energy with the external world.
3. Metabolic machinery for sustaining life activities such as growth, reproduction and repair of parts.

Viruses do not fit in easily with these parameters of a true cell.



**Animal Cell**

An animal cell typically contains several types of membrane-bound organs, or organelles. The nucleus directs activities of the cell and carries genetic information from generation to generation. The mitochondria generate energy for the cell. Proteins are manufactured by ribosomes, which are bound to the rough endoplasmic reticulum or float free in the cytoplasm. The Golgi apparatus modifies, packages, and distributes proteins while lysosomes store enzymes for digesting food. The entire cell is wrapped in a lipid membrane that selectively permits materials to pass in and out of the cytoplasm.



**Plant Cell**

Plant cells contain a variety of membrane-bound structures called organelles. These include a nucleus that carries genetic material; mitochondria that generate energy; ribosomes that manufacture proteins; smooth endoplasmic reticulum that manufactures lipids used for making membranes and storing energy; and a thin lipid membrane that surrounds the cell. Plant cells also contain chloroplasts that capture energy from sunlight and a single fluid-filled vacuole that stores compounds and helps in plant growth. Plant cells are surrounded by a rigid cell wall that protects the cell and maintains its shape.

**DIFFERENCES BETWEEN PROKARYOTIC AND EUKARYOTIC CELLS**

 **FEATURES** **PROKARYOTIC** EUKARYOTIC

 1. Size Mostly between 1- 10µm in size Mostly between 10 –

 100µm

2. Multicellular forms Rare Common, with extensive

 tissue formation

3. Cell wall Cell wall present in most, not in all Only in plant and fungal cells cells

4. Plasma membrane Plasma membrane is present Present

5. Nucleus Absence of nucleus Presence of nucleus

6. Nuclear membrane Absence of nuclear membrane Presence of nuclear membrane

7. Chromatin with Chromatin with histone is absent Presence of chromatin with histone. histone.

8. Genetic material Circular or linear, double stranded Linear double stranded DNA,

 DNA genes frequently interrupted intron sequences especially

 higher Eukaryotes

9. Nucleoli & mitotic Absence of nucleoli & mitotic appar - Presence

 apparatus -atus

10. Plasmids Plasmids are common Rare

11. Cellular organelles Mostly absence of cellular organelles Presence of cellular organelles, ribosomes except ribosomes that are present in 70s ribosomes in 80s

12. Respiration Many strict anaerobes (oxygen fatal) All are aerobic, some facultative

 anaerobes.

**TYPES OF CELLULAR ORGANELLES**

1. Plasma membrane and Cell wall
2. Endoplasmic Reticulum (ER)
3. Golgi apparatus/complex
4. Lysosomes
5. Mitochondria
6. Plastids (chloroplasts and vacuoles)
7. Nucleus
8. Chromosomes

(9) Ribosomes

(10) Centrioles & Basal bodies

 (11) Cilia & Flagella

 (12) Vacuoles

 (13) Peroxisomes & Glycoxysomes

**FUNCTIONS OF CELLULAR ORGANELLES**

(1). **PLASMA MEMBRANE (& CELL WALL)**:

Plasma membrane – Cytoplasmic membrane/ cell membrane- coined by C. Nageli & C. Cramer (1855); Plasma lemma given by J.Q. Plowe (1931).

Plasma membrane encloses every type of cell whether Prokaryotic or Eukaryotic cells.

(i) Separates the cytoplasm from the surrounding cellular environment.

 It is an ultrathin, elastic, living, dynamic and selective transport – barrier.

 A fluid-mosaic assembly of molecules of lipids (phospholipids and cholesterol), proteins ` and (CH2O)n.

(ii). Controls the entry of nutrients and exit of waste products.

(iii). Generates differences in ion concentration between the interior and exterior of

 the cell (permeability).

(iv). Acts as a sensor of external signals (e.g. hormonal & immunological etc.) and

 allows the cell to react/change in response to environmental signals.

- For bacteria and plants, p.m. is between the cell wall and cytoplasm.

- For cells having no cell walls (e.g. mycoplasma & animal cells), plasma

membrane forms the cell surface.

Examples of cell used in studying plasma membrane are mammalian red blood cell (erythrocytes), medullated nerve fibers, liver cells, striated muscle, *Amoeba proteus*, Sea urchin eggs and bacteria.

**Types of plasma membrane according to permeability**:

**Impermeable plasma membrane** e.g. unfertilized eggs of certain fishes allow nothing except

gases to pass through it.

**Semi permeable plasma membrane** – allows only H2O but no solute to pass through it.

**Dialyzing plasma membrane** – having extraneous coats around them which serves as a

dialyzer. i.e. H2O molecules & crystalloids are forced through them by the hydrostatic pressure forces e.g. basement membrane of endothelial cells.

**Mode of transport through plasma membrane:**

**Passive transport**: a type of diffusion in which an ion/molecule crossing a membrane moves down its electrochemical or concentration gradient. No metabolic energy is consumed on passive transport and is of 3 types namely:

1. **Osmosis** (2). **Simple diffusion** (3). **Facilitated diffusion**, a special type of passive transport in which ions and molecules cross the membrane rapidly because specific permeases in the membrane facilitate their crossing. e. g. ionic transport through charged pores.

(2). **ENDOPLASMIC RETICULUM (ER) L.** Greek: endo = within; plasma = body;

Reticulum = net

**Structure**: sheets of unit membrane with ribosomes on the outside; forms a tubular network throughout the cell.

**Function**: transports chemicals between cells and within cells.

provides a large surface area for the organization of chemical reactions and synthesis.

The cytoplasmic matrix is traversed by a complex network of interconnecting membrane bound vacuoles/cavities which are often concentrated in the endoplasmic portion therefore called ER b/c it resembles a “net” in the cytoplasm under light microscope

- Occurrence of ER varies from cell to cell.

- The erythrocytes (RBC), egg and embryonic cells have no ER.

- In reticulocytes (immature RBC) which produce only proteins retained in the cytoplasmic matrix (cytosol) e.g. hemoglobin), the ER is poorly developed or non-existent but may contain many ribosomes.

- The ER acts as a secretory, storage, circulatory & nervous system to the cell.

(3). **GOLGI APPARATUS/COMPLEX**

Tagged/referred to as the **“traffic police”** of the cell (Darnell et al., 1986)

**Structure:** These are stacks of flattened sacs of unit membrane (cisternae)

Vesicles pinch off the edges.

**Occurrence**: Found in plant and animal cells’ cytoplasm;

* occurs in all cells except the prokaryotic cells (e. g. mycoplasmas, bacteria), eukaryotic cells of certain fungi, sperm cells of Bryophytes and Pteridophytes, cells of mature sieve tubes of plants, mature sperm & red blood cells of animals.

**Function**: Modifies chemicals to make them functional.

* Secretes chemicals in tiny vesicles.
* Stores chemicals.
* May produce endoplasmic reticulum.
* Golgi apparatus is responsible for the performance of certain important cellular functions e.g. biosynthesis of polysaccharides, packaging (compartmentalizing) of cellular synthetic products (proteins), production of exocytotic (secretory) vesicles and differentiation of cellular membranes.
* Golgi apparatus is a centre of reception, finishing, packaging and dispatch for a variety of materials in animals’& plants’ cells.

(4). **LYSOSOMES**: (Gr. Lyso = digestive + soma = body)

**Structure**: membrane bound bag containing hydrolytic enzymes.

Hydrolytic enzyme is water split biological catalyst i.e. using water to split chemical bonds.

Lysosome – lytic body having digestive enzymes capable of lysis i.e dissolution of a cell/tissue (De Roberts & De Robertos Jr. 1987).

* + These are tiny membrane-bound vesicles involved in intracellular digestion.
	+ Contain a lot of (variety of) hydrolytic enzymes that remain active under acidic conditions.

**Functions**:

* Break large molecules into small molecules by inserting a molecule of

 water into the chemical bond.

* Primarily meant for the digestion of a variety of biological materials.
* Secondarily causing aging and death of animal cells, human diseases e.g. cancer, gout,

 silicosis.

(5). **MITOCHONDRIA** (Gr, mito = thread, chondrion = granule)

**Structure:**

* Composed of modified double unit membrane (protein, lipid)
* Inner membrane infolded to form cristae.
* They are filamentous or granular cytoplasmic organelles of all aerobic cells of higher animals, plants and certain microorganisms e.g. Algae, Protozoa and Fungi. Absent in bacterial cells.
* Contain a specific DNA for cytoplasmic inheritance and ribosomes for protein synthesis.
* Have uniform distribution in the cytoplasm (move autonomously in the cytoplasm)
* Distribution and number of mitochondria (& also of mitochondria cristae) is correlated with the type of function the cell performs.
	+ Mitochondria having many cristae are associated with mechanical & osmotic work situations, where there are **sustained demands of ATP** and where space is at a premium e.g. between muscle fibres, basal infolding of kidney tubule cells, and in a portion of inner segment of rod and cone cells of retina.
	+ Usually, mitochondria occur in greater concentrations at work sites.
	+ In animal cells, 95% ATP is produced by the mitochondria; the remaining 5% is produced during **anaerobic respiration** outside the mitochondria.
	+ ATP can be produced by chloroplasts in plant cells.

**Function:**

* Site of cellular respiration i.e. the release of chemical energy from food.
* Actual respiratory organs of the cells, helps in oxidizing carbohydrates (CH2O)n and fats (food stuffs) into CO2 and H2O and large amount of energy is released which the mitochondria utilize for the synthesis of energy rich compound, Adenosine Triphosphate (ATP); because of production of ATP, mitochondria are referred to as the “**Power houses**” of the cell.

**Glucose+ Oxygen  Carbon Dioxide + Water + Energy (ATP)**

(6). **PLASTIDS**

Two membrane-bounded compartments – vacuoles & plastids readily distinguish

plant cells from animal cells; are related to the immobile life – style of plant cells.

**Structure of chloroplast:** composed of a double layer of modified membrane (protein, chlorophyll, lipid); inner membrane invaginates to form layers called “grana” (sing., granum) where chlorophyll is concentrated.

* Present in all living plant cells & in Euglena (a protozoan)
* Small bodies found free in the cytoplasm, more/less spherical or disc shaped

(1µm - 1mm in diameter)

* May be elongated or lobed or show amoeboid characteristics.
* Double-bounding membranes, possession of pastoglobuli (spherical lipid

droplet) is another identifying factor.

* A self-replicating organelles whose protein-synthesizing capacity is

comparable to that of mitochondria.

**Functions of chloroplasts**: site of photosynthesis (light & dark reactions)

(7). **NUCLEUS** (L., nux = nut) – the “heart” of the cell.

**Structure**: The nucleus consists of the nuclear material envelope, nucleolus, chromatin and nucleoplasm.

**Functions**:

- Almost all the cells’ DNA is confined, replicated & transcribed.

- Controls diff metabolic as well as hereditary activities of the cell, synonymous to Greek

word “karyon”.

* Serves as main distinguishing feature of eukaryotic cells.

(8). **CHROMOSOMES**

These are the nuclear components of special organization, individuality and function.

**Functions**: They are capable of self-reproduction and play a vital role in heredity, mutation, variation & evolutionary development of the species.

(9). **RIBOSOMES**

- Small, dense, rounded & granular particles of the ribonucleic protein.

- Occur freely in the matrix of mitochondria, chloroplast and cytoplasm (matrix) or remains ` attached with the membranes of the ER and nucleus.

 - Occur in most prokaryotic and eukaryotic cells.

**Functions**: Known to provide a scaffold for the ordered interaction of all the molecules involved in protein synthesis i.e. in the biosynthesis of proteins.

(10). **CENTRIOLES AND BASAL BODIES**

Cytoplasm of some eukaryotic cells contains 2 cylindrical, rod-shaped, microtubular structures called centrioles, near the nucleus. They lack limiting membrane and DNA or RNA and form a spindle of microtubules, the mitotic apparatus during mitosis/meiosis and sometimes get arranged just beneath the plasma membrane to form and bear flagella and cilia in flagellated/ciliated cells (Futton 1971).

**Stucture**: Nine triplets of microtubules form one centriole; two centrioles form one centrosome.

**Function**: Forms spindle fibres to separate chromosomes during cell division.

When the centriole bears a flagellum/cilium is referred to as a basal body.

synonymous to kinetosome, blepharoplast, basal granule/corpuscle & proximal centriole.

(11). **CILIA & FLAGELLA**

 **Structure**: The cilia (L. cili = eyelash) and flagella (L. Little whip) are microscopic, contractile & filamentous processes of the cytoplasm which create:

* Food currents in lower aquatic animals.
* Act as sensory organs.
* Perform many mechanical functions of the cell.
* The ciliary or flagella movement provides the locomotion to the cell/organism.

The two (2) are identical morphologically & physiologically but can be distinguished by their number, size and functions.

* Flagella are less (1 or 2) in no while cilia are numerous (3000 – 14000 or more) in number.
* Flagella occur at one end of the cell, while the cilia may occur throughout the surface of the cell.
* Flagella are longer (up to 150µm) processes while the cilia are short (5 – 10µm) appendages of the cytoplasm.
* Flagella usually beat independently, while the cilia tend to beat in a coordinated rhythm.
* Flagella exhibit un-dulatory motion, while the cilia move in a sweeping/pendula stroke.

(12). **Vacuole**: This is a single layer of unit membrane enclosing fluid in a sack.

**Functions:**

* Produces turgor pressure against cell wall for support.
* Stores water and various chemicals.
* May store insoluble wastes.

(13). **MICROBODIES**:

**Structure**: There is the presence of membrane bound, spherical bodies of 0.2 – 1.5µm diameter in close association of ER and mitochondria or chloroplast or both in cells of protozoa, fungi, plants, liver and kidney of vertebrates.

* The organelles have a **central granular/crystalloid core** containing some enzymes & called **microbodies**.
* These organelles are surrounded only by a single membrane which have no DNA (genome) or ribosomes.
* They use molecular O2 like mitochondria but have flavin-linked oxides and catalases for the H2O2 metabolism and enzyme for fatty acid metabolism instead of cytochromes and capacity for ATP synthesis as in mitochondria.
* Peroxisomes and Glycoxysomes both differ in cell compartment and in the type of tissue in which they are found.
* Peroxisomes are found in animal cells and leaves of higher plants.
* Glycoxysomes present in plant cells only and abundant in germinating seeds that store fat as a reserve food material, cells of yeast, Neurospora (fungus) and oil rich seeds of many higher plants.

**FUNCTIONS OF PEROXISOMES**

1. H2O2metabolism 2. Glycolate cycle 3. β-oxidation

**FUNCTIONS OF GLYCOXYSOMES**

1. Fatty acid metabolism 2. β-oxidation 3. Glycoxylate cycle