8. Cell - The Basic Unit of Life

1. Tools and Techniques

In the course of history of biology, various new tools and techniques have been developed to explore more and ease out the studies. These include instruments and processes like microscopy, chromatography, electrophoresis etc.

1.1. Microscopy

Microscope are instruments consisting of lenses (made of glass / Lithium fluoride / electromagnetic lens) which magnify and resolve small objects not visible to unaided eye for the study of their details. The term microscope was coined by Faber in 1625.

- **Magnification:** It is the degree of enlargement or the ratio of size of the object as seen in the microscope to its actual size.

$$\text{Magnification} = \frac{\text{Size of the image with the instrument}}{\text{Size of the image with unaided eye}}$$

Magnification of a microscope is roughly equal to the multiple of magnifying power of objective lens and ocular lens (eye piece) *e.g.*, if the magnification power of an ocular lens is $10X$ and of the objective is $40X$, then the total magnifying power of a microscope is $10 \times 40 = 400X$ (the magnification power of a microscope is represented by the symbol 'X').

- **Resolving power:** It is the ability of a system to distinguish two close objects as two distinct objects. Its value is calculated by *Abbe* equation –

$$L_m = \frac{0.61\lambda}{NA}$$

Here, λ – is wavelength of used light, NA – Numerical Aperture, $(NA = n\sin\theta)$

Numerical aperture is multiple of refractive index of medium (n) and $\sin\theta$, which is sine of angle substended by optical axis and outer ray covered by objective. The value for best objective $\sin 70° = 0.94$. Resolving power of a light microscope ranges from $0.2\mu m$ to $0.4\mu m$ in blue light. The resolving power of human eye is $100\mu m$ or microns (0.1 *mm*). This means that two points less than $100\mu m$ apart appear as one point to our eyes.

Father of microscopy is *Leeuwenhoek*. He built first 270 *X* magnification microscope in 1672.

1.2. Types of microscopes

- **Simple microscope:** It is also known as magnifying glass and consists of a convergent lens. *Leeuwenhoek* (1683) designed a primitive microscope and discovered cells with it. Its magnification power was 14 – 42 times only, so it is considered as simple microscope.
- **Compound microscope or Light microscope:** The first compound microscope was assembled by *Zacharias Janssen* and *J. Janssen*, the Dutch spectacles makes in 1590. The compound microscope was prepared by *Kepler* and *Galileo* in 1611. It is simplest, widely used microscope having three lens *i.e.*, condensor, which collects the light rays and precisely focuses them on the objects; objective lens, which magnifies the image by three objective lenses, *i.e.*, low power (10x), high power (45x) and oil immersion lenses. In a compound microscope an object can be magnified upto 1000 times. The light microscope is also called *bright field* microscope because it forms the image when light is transmitted through the object.
- **Fluorescent microscope:** It was developed by *Coons* (1945). It is observed that when ultraviolet light is irradiated on certain chemical substances, they absorb it and emit visible light. These chemical substances are called fluoro-chromes. The fluorescent substances *e.g.*, quinine sulphate, rhodamine and auramine are used to stain the cellular objects and these objects are easily visible as fluorescent areas when illuminated with ultraviolet light.
- **Polarizing microscope:** It was invented by *Tolbart*. In this microscope the plane polarised light is used as a source of illumination. Unlike the ordinary light, plane polarised light vibrates only in one direction and the cellular objects are easily visible as they appear bright against the dark ground. Polarizing microscope is helpful in studying the spindle fibres in the cells.
- **Ultraviolet microscope:** It was invented by *Caspersson*. In this microscope the source of illumination is ultraviolet radiations having shorter wavelengths (1500 Å – 3500 Å) as compared to ordinary visible light. In this microscope, the lenses are made of fluoride, lithium fluoride or quartz instead of glass. Ultraviolet microscope is helpful in quantitative determination of all those cell components which absorb ultraviolet rays.
- **Phase contrast microscope: Discovered** by Dutch man *Fredericke Zernicke* (1935). Source of illumination is visible light. It is used to study living cells and tissues without staining and effect of chemical and physical agents on the living cells. It is also used to study spindle formation, pinocytosis, karyokinesis, cytokinesis etc. The demerit of this microscope is subcellular organelles smaller than 0.2μ, (like ribosomes, lysosomes, ER) cannot be visualised.
- **Interference microscope (Morten et.al.):** It's principle is similar to that of the phase contrast microscope and gives / studies quantitative data. Nomarski interference contrast microscope is useful to study mitosis /cell components in living state. It gives better image of living structures. It is also used to measure thickness of the cell and determination of several light absorbing chemicals like nucleic acid, proteins, lipids etc.
- **Dark field microscope:** *Zsigmondy* (1905) invented this microscope. It is based on the fact that light is scattered at boundaries between regions having different refractive index. The object smaller than those seen with ordinary light microscope can be detected but cannot be resolved.

- **Electron microscope:** This was developed by *M. Knoll* and *E. Ruska* (1931) in Germany. It is the best device to determine the ultrastructure of a cell organelle. It is a large sized instrument which has an internal vacuum, high voltage (50,000 – 1,00,000 volts), a cooling system, a fast beam of electrons (0.54 Å wavelength), a cathode filaments of tungsten and electromagnetic lens (which having a coil of wire enclosed in soft iron casing) for focusing. Ribosomes can be seen only in electron microscope.
  Thus an electron microscope essentially comprises an electron gun and electron lenses. The electron gun is the source of electrons consisting of a heated tungsten filament. It is preferred because it can be heated upto 3000°C. The electron beam can be reflected by magnetic field. Therefore, a very powerful magnetic coil acts as lens. The focal length of the electromagnetic lenses change with the wavelength of illumination. Since the wavelength is controlled by the voltage, it should be controlled and made constant. Three types of magnetic lenses are used namely projector, objective and condenser. For viewing objects under EM, ultrathin sections (20-100 *nm* thick) are prepared through an ultra microtone. It was first developed by W.His.
  Electron microscope can magnify the objects upto 2,00,000 times (now possible upto 2,50,000 – 4,00,000) and direct study of objects is possible on this microscope. The resolving power of electron microscope is 10 Å which is 100 times more than the light microscope. Study of living cells cannot be done through this microscope because of high voltage, which is required to operate it, kills the living materials. Electron microscope are of two types :
  (a) **Transmission electron microscope (TEM) :** It was the first microscope developed by *Ruska* (1932). It produces two dimensional images. Magnification of TEM is 1–3 *lakh* and resolving power is 2–10Å. Because of them transmission electron microscope has helped in the discovery of a number of small cell organelles *e.g.*, ER, ribosomes, centrioles, microtubules etc. Detail structure of larger cell organelles could also be known only with the help of TEM. *e.g.*, chloroplast (thylakoids), mitochondria (elementary particles, DNA), ribosomes etc.
  (b) **Scanning electron microscope (SEM) :** This microscope was invented by *Knoll* (1935). It gives three dimensional image. The specimen to be studied is first super cooled (in liquid propane at –180°C) and dehydrated in alcohol (at –70°C). It is then coated with gold, platinum or some other metals for creating a reflecting surface for electrons. Magnification of SEM varies from 15 – 2,00,000. Resolution power is 5 – 20 *nm*.
- **Advanced high power microscope**
  (a) **Scanning probe microscope:** The microscope is capable of resolving the outer texture of the material to the minutest detail since it has the potential to image even a single atom. Magnification is upto 100 million.
  (b) **Scanning tunneling microscope:** It has a tiny tungsten probe for moving over the surface of specimen. The microscope is used to detect defect in electrical conductors and computer chips.
  (c) **Atomic force microscope:** It has an extremely fine diamond probe for moving over the surface of biochemicals. Oscillations produced in the probe are changed into images by a computer. The microscope is useful in viewing detailed structure of biological molecules, *e.g.*, DNA, proteins, etc.

1.3. Units of measurement used in microscopy

1 micron (μ) = 10^{-6} or one millionth

1 micrometer (μm) = $10^{-6}\,m$, $10^{-4}\,cm$, $10^{-3}\,mm = 1000\,nm$

1 Nanometer (nm) = $10^{-9}\,m$, $10^{-7}\,cm$, $10^{-6}\,mm$, $10^{-3}\,\mu m = 10\,Å$

1 Angstrom (Å) = $10^{-10}\,m$, $10^{-8}\,cm$, $10^{-7}\,mm$, $10^{-4}\,\mu m$,

1 Picometer (pm) = $10^{-12}\,m$, $10^{-3}\,nm$

1 Femtometer (fm) = $10^{-15}\,m$, $10^{-6}\,nm$

1 Attometer = $10^{-18}\,m$, $10^{-9}\,nm$

Common unit of measurement in Microscopy and cytology is *nanometer* while unit of measurement of cell is *micron*.

Some important Cytochemical Stains

Stain	Used for staining	Final colour
Acetocarmine	Chromosomes	Pink
Acid fuchsine	Cortex, cellular walls, mitochondria	Magenta
Aniline blue	Fungal hyphae	Blue
Basic fuchsine	Nucleus	Magenta red
Crystal violet	Bacteria	Violet
Eosin	Cytoplasm	Pink
Feulgen's stain	DNA	Purple/Red
Hemotoxyline	Nuclei, cell wall, cellulose	Violet
Iodine solution	Starch	Blue
Janus green	Fungi and mitochondria	Green
Methylene blue	Yeast and Golgi complex	Blue
Phloroglucinol +HCl	Lignin	Red
Ruthenium red	Pectin	Red
Safranin	Nuclei, lignified tissue	Red
Sudan- III or IV	Suberin, cutin, oil	Red
Sudan black	Fatty substance	Black
Toludine blue	RNA	Blue
Cotton blue	Fungi	Violet

1.4. Cytochemistry

A number of dyes or stains are known to colour specific parts. Certain dyes can be used even in case of living materials. They are called vital stains, *e.g.*, neutral red, methylene blue. Fuelgen or Schiff's reaction was developed by *Fuelgen* and *Rossenbeck* (1924). Identification and localization of chemical compounds of a cell is studied in cytochemistry.

1.5. Cell fractionation

- **Homogenisation :** Cell products are separated in isotonic medium (0.25 M sucrose solution) either with the help of homogeniser of ultrasonic vibrations kept at 0 – 4°C. A homogenised cell is called homogenate.
- **Differential centrifugation :** Homogenisation product is rotated (centrifuged) at different speeds. The sediment or pellete of each speed is collected. *e.g.*, nuclei at $1000 \times g$ (g= force of gravity) for 10 minutes, chloroplast and mitochondria at $10{,}000 \times g$ for 15 minutes. The particle settle according to their sedimentation ratios. Sedimentation coefficient is expressed in svedberg unit 'S' related with molecular weight of the particles. For the detail study of mitochondria it is the best technique. '*S*' is measured by analytical centrifugation.

  The various cell organelles and macromolecules sediment in the following order.

  Nucleus→Chloroplast→Mitochondria→Ribosome→DNA→mRNA→tRNA

1.6. Chromatography

Discovered by Michael Tswett (1906). This technique is used to separate the molecules of different substances present together. Mixture of molecules is run over an adsorption medium. Chromatography may be following types.

- **Adsorption or Column chromatography:** The stationary phase consists of a column of charcoal, silica, alumina, calcium carbonate or magnesium oxide. The solution is made to percolate through this column when different chemicals get absorbed at various levels. The technique is useful for separation of tissue lipids.
- **Thin layer chromatography (TLC):** The stationary phase consists of a thin plate of cellulose powder or alumina. As a few drops of mixture are poured over it, the different chemicals spread to different distances. The method is useful in separation of amino acids, nucleotides and other low molecular weight products.
- **Paper chromatography :** A paste of mixture is applied near one end of a chromatographic paper (or Whatman 1). The lower end below the paste is dipped in a solvent. As the solvent rises in chromatographic paper, the different chemicals of the mixture spread to different distances. The paper can be rotated to obtain two dimensional chromatogram.

  Types : (a) Ascending (b) Descending (c) 2-D chromatography.

  (a) Ion exchange chromatography : Beads of cellulose and other materials having negative and positive charges are placed in a column. The mixture (mobile phase) is poured over the column. As the mixture passes through the column, its constituents separate according to their charges. The technique is used in purification of insulin, plasma fractionation and separation of proteins.

  (b) Gel fractionation / Gel filtration chromatography (Molecular sieve chromatography) : The stationary phase consists of gel forming hydrophilic beads which contain pores, *e.g.*, sephadex (cross-linked dextran). As the mixture is poured over the gel, larger molecules pass out unimpeded while small molecules are trapped in the pores. The technique is used in separation of proteins. It is also employed in determining their molecular weight by calibrating the column with proteins of known molecular weight.

  (c) Affinity chromatography : Stationary phase consists of column of ligands (molecules that bind to other specific molecules at particular sites). Mixture is allowed to pass through the column. Chemical linkages are established between ligands and their specific chemicals. Others pass out of the column. The technique is used in separation of enzymes, immunoglobulins, *m*RNA, etc.

1.7. Electrophoresis

It is an another technique of separation in which patricles of different charges and sizes are separated under the influence of electric field. *e.g.*, nucleic acids, proteins, amino acids, nucleotides can be separated by this method. The technique was discovered by Russian physicist *Alexender Reuss* in 1807.

1.8. Autoradiography

It is a technique of studying the route of chemicals in chemical reactions taking place inside the cell and organisms with the help of radioactive isotope. *e.g.*, ^{14}C, ^{3}H, ^{32}P. In this technique the radioisotopes are incorporated into the precursor molecule. Then the labelled precursor molecules introduced into the cells and their path is followed with the help of their radiations. Radioactive precursors emit radiations and their position in the cell is located by bringing the cell in contact with a photographic plate or film. ^{32}P and ^{14}C are used for the study of nucleic acids and photosynthesis (Melvin Calvin) respectively.

1.9. Radioisotope or Tracer technique

They are unstable isotopes which function like normal elements but emit positive or negative particles, *e.g.*, ^{3}H (Tritium), ^{14}C (Carbon), ^{32}P (Phosphorus), ^{35}S (Sulphur), ^{42}K (Potassium), ^{131}I (Iodine). Radioactivity is recorded in different parts by Geiger counter or scintillation counter or autoradiography to know regions of use and transport. The tracers have been used for knowing pathway of mineral transport (Stout and Hoagland, 1939), organic solute transport (Vernon and Aronoff, 1952), carbon assimilation (Calvin, 1955). Where radioactive elements are not available, heavy isotopes are used, *e.g.*, ^{15}N, ^{18}O.

1.10. X-ray Crystallography

It was developed by the *Bragg* (1913). They can be used as a tool for determining the arrangement of atoms in various biological molecules. By using this technique *Wilkins et al.*, 1953 found out details of the DNA molecule for which he was also awarded Nobel Prize along with *Watson* and *Crick* in 1962. *Kendrew*, 1957 by using the same technique studied the molecules of myoglobin.

2. Cell : The Unit of Life

Cytology (Gk *Kytos* = cell ; *logos* = study) **:** It is the branch of biology, which comprises the study of cell structure and function. "*Cell is the* structural and functional unit of all living beings". Study of metabolic aspects of cell components is called cell biology.
Robert Hooke (1665) discovered hollow cavities (empty boxes) like compartments in a very thin slice of cork (cell wall) under his microscope. He wrote a book "*Micrographia*" and coined the term cellula, which was later changed into cell. *Grew and Malpighi* also observed small structures in slice of plants and animals. *Leeuwenhoek* was the first to see *free cells* and called them "wild animalcules" and published a book "The secret of nature". He observed bacteria, protozoa, RBCs, sperms, etc. under his microscope.

2.1. Cell theory

The actual credit for cell theory goes to two German scientists, a Botanist *M.J. Schleiden* (1838) and a Zoologist *T. Schwann* (1839). They gave the concept "all living organisms are composed of cell". *Schleiden* and *Schwann* both supported the theory of "spontaneous generation". They also mentioned that "the new cell arises from nucleus by budding".

Exceptions to the cell theory : Viruses, viroids and prions are an exception to the cell theory as they are obligate parasites (sub–cellular in nature).

Modification of cell theory : Modification of cell theory was done by *Rudolf Virchow* (1855). He proposed the "law of cell lineage" which states that cell originates from pre-existing cells. *i.e.,* (*omnis cellula-e-cellula*). It is also called "cell principle" or "cell doctrine". It states :

(1) Life exists only in cells.

(2) Membrane bound cell organelles of the protoplasm do not survive alone or outside the protoplasm.

(3) Cells never arise *de novo*. The new cells are like the parent cell in all respect.

(4) All cells have similar fundamental structure and metabolic reactions.

(5) Cells display homeostasis and remain alive.

(6) Genetic information is stored in DNA and expressed within the cells.

(7) DNA controls structure and working of a cell.

Cellular totipotency : Totipotency was suggested by *Haberlandt* (1902). When cells have tendency or ability to divide and redivide the condition of the cell is called totipotent and this phenomenon is called *totipotency*. *Steward et.al.* showed the phenomenon of cellular totipotency in phloem tissue of carrot.

Surface volume ratio : Metabolically active cells are small, as small cells have higher nucleocytoplasmic ratio for better control and higher surface volume ratio for quicker exchange of materials between the cell and its outside environment. Larger cells have lower surface volume ratio as well as lower nucleocytoplasmic ratio. Surface volume ratio decreases if cell size increases.

Differences between plant and animal cell

Plant cell	Animal cell
Cell wall present.	Cell wall absent.
Nucleus usually lies near periphery due to vacuole.	Nucleus present near the centre.
Centrosome is usually absent from higher plant cells, except lower motile cells.	Usually centrosome is present that helps in formation of spindle fibres.
Plastids are present, except fungi.	Plastids are absent.
Mitochondria is generally spherical or oval in shape.	Generally tubular in shape.
Single large central vacuole is present.	Many vacuoles occurs, which are smaller in size.
Cytoplasm during cell division usually divides by cell plate method.	Cytoplasm divides by furrowing or cleavage method.
Plant cells are capable of forming all the amino acids, coenzymes and vitamins.	Animal cells cannot form all the amino acids, coenzymes and vitamins.
There is no contractile vacuole.	Contractile vacuole may occur to pump excess water.
Spindle formed during cell division is anastral.	Spindle formed during cell division are amphiastral.

2.2. Cell Size

Cells differ greatly in size, shape and activities.

Cells also vary greatly in their shape. They may be disc like, polygonal, columnar, cuboid, thread like or even irregular. The shape of the cell may vary with the function they perform.

(1) **Smallest cell**----Mycoplasma (PPLO)

(2) **Largest cell** -----Ostrich Egg (170 × 150 mm),

(3) **Longest cell** ---- Hemp fiber (1m) – Boehmeria Nivea

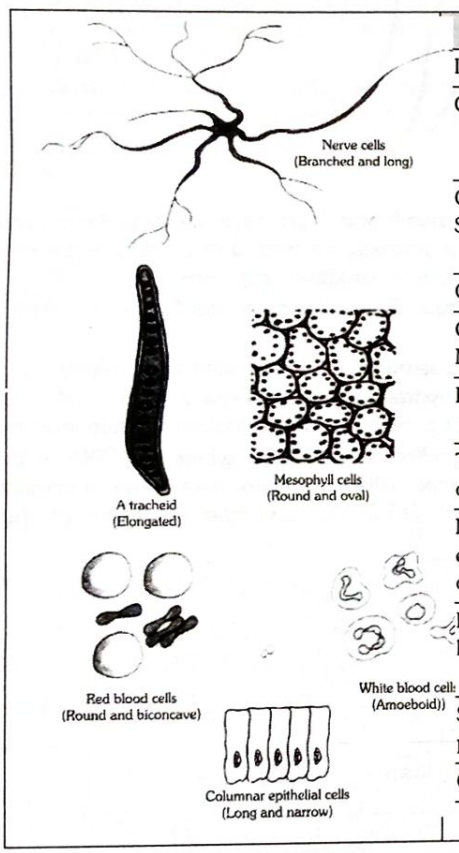
(4) **Longest Human cell**------ nerve cell (90 cm)

(5) **Smallest Human cell**-----RBC (7 μm)

2.3. Types of cells

Chatton gave the term prokaryote and eukaryote. Depending upon the nature of nucleus, cells are classified. Incipient nucleus is present in prokaryotes, where as in eukaryotes well organised nucleus is present.

Differences between prokaryotic and eukaryotic cell



Prokaryotic cell	Eukaryotic cell
It is a single membrane system.	It is a double membrane system.
Cell wall surrounds the plasma membrane.	Cell wall surrounds the plasma membrane in some protists, most fungi and all plant cell. Animal cell lacks it.
Cell wall is composed of peptidoglycans. Strengthening material is murein.	It is composed of polysaccharide. Strengthening material is chitin in fungi and cellulose in other plants.
Cell membrane bears respiratory enzymes.	It lacks respiratory enzymes.
Cytoplasm lacks cell organelles *e.g.*, Mitochondria, ER, Golgi body etc.	Cytoplasm contains various cell organelles.
Ribosomes are only 70 S type.	Ribosomes are both 80 S and 70 S type.
There are no streaming movements of cytoplasm.	Cytoplasm show streaming movements.
Nuclear material is not enclosed by nuclear envelope and lies directly in cytoplasm. It is called nucleoid.	It is enveloped by nuclear envelope. Nucleus is distinct from cytoplasm.
DNA is circular and not associated with histone proteins.	Nuclear DNA is linear and associated with histone proteins extranuclear DNA is circular and histone protein free.
Sexual reproduction absent but parasexuality present.	Sexual reproduction is present.
Cell division mostly amitotic.	Cell division is typically mitotic.

Mesokaryon : *Dodge* gave the term 'Mesokaryon' for dinoflagellates. These are intermediate type of cell organisation in dinophyceae of algae. In mesokaryotic there is present a true or eukaryotic nucleus with definite nuclear membrane and chromosomes.

- **Prokaryotic cells**

  Prokaryotic cells fall into a size range of about 1–5μm and hence can be observed clearly by microscopes. However, some prokaryotic cells may be larger than this. A prokaryotic cell contains external and internal structures. Capsule, flagella, axial filaments, fimbriae, and pili are present external to the cell wall, while interior of the bacterial cell contains cytoplasm.

  (a) **Flagella –** Flagella are whip like structures made of protein and provide motility to the cell. Prokaryotic cells may be

  (b) Monotrichous – Cells that have one flagellum.

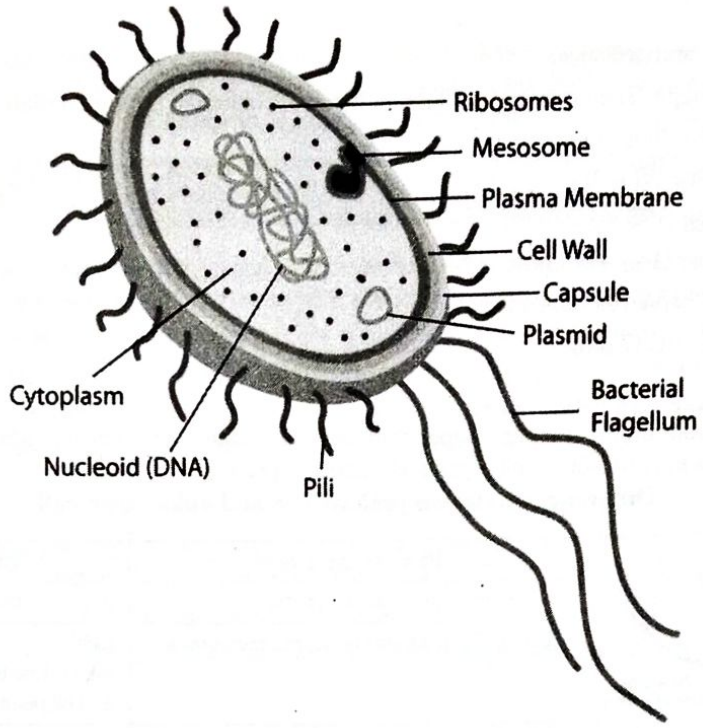
  (c) Lophotrichous – Cells that have a clump of flagella known as tuft, at one end of the cell.

  (d) Amphitrichous – Cells that have flagella at two ends of the cell.

  (e) Peritrichous – Cells that have flagella covering the entire cell on the surface.

  (f) **Fimbriae and pili –** Fimbriae are proteinaceous, sticky, projected structure used by cells to attach to each other and to objects around them, while pili are tubules that are used to transfer DNA from one cell to another cell.

  (g) **Capsule** Depending on the type of bacterium, there may be an exterior surrounding layer such as a capsule or slime layer, made of glycocalyx.

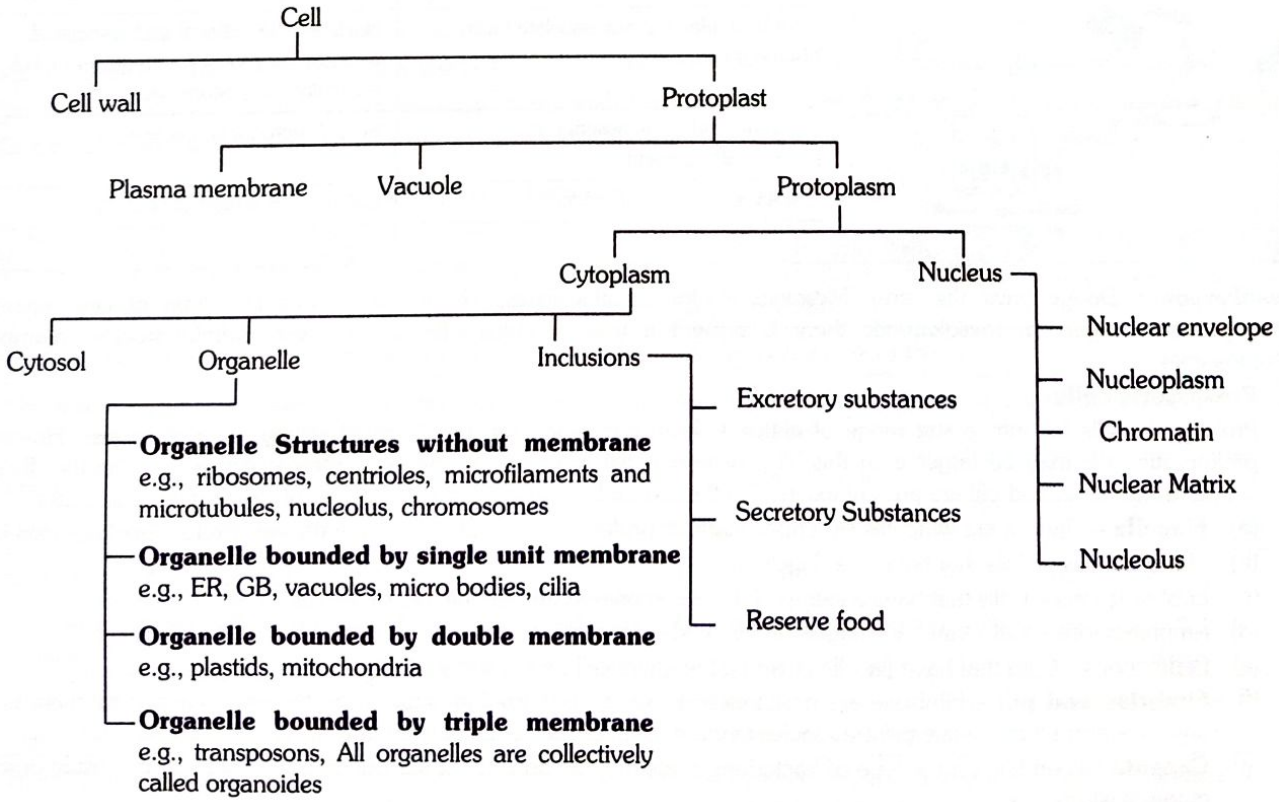


(h) **Cell wall –** The prokaryotic cell's cell wall is present outside the plasma membrane. It provides rigidity to the cell shape and structure and protects the cell from its environment. Bacterial cell wall is primarily composed of peptidoglycan and on the basis of cell wall composition the bacteria classified into gram-positive and gram negative organisms.

(i) **Cytoplasmic Membrane –** The cytoplasmic membrane is a membrane that provides a selective barrier between the environment and the cell's internal structures.

(j) Cytoplasm- Cytoplasm is thick, aqueous, semitransparent, and elastic semifluid present inside the prokaryotic cell. It is about 80% water and contains primarily proteins (enzymes), carbohydrates, lipids, inorganic ions, and many low-molecular-weight compounds. Inorganic ions are present in much higher concentrations in cytoplasm than in most media.

(k) **Nucleoid/Genetic material –** The cytoplasm also contains a region called the nucleoid, where the DNA of the cell is located. The prokaryotic cell consists of a chromosome that isn't contained within a nuclear membrane or envelope. The nucleoid or bacterial chromosome comprises a closed circle of double stranded DNA, many times the length of the cell is highly folded and compacted.



(l) **Ribosomes –** Ribosomes are the principle structure in a prokaryotic cell after the nucleoid. They are composed of a complex of protein and RNA, and are the site of protein synthesis in the cell. The prokaryotic ribosomes are 70S, comprised of sub units 50S and 30S (S stands for the svedberg coefficient which is a function of their size and shape, and determined by their rate of sedimentation in a centrifuge)

(m) **Inclusion bodies –** Many granular structures known as inclusion bodies are found in the cytoplasm of certain bacteria. These contain organic compounds such as starch, glycogen or lipid and act as food reserves. Some sulphur and polyphosphate containing bodies are also found and are known as metachromatic granules.

(n) **Endospore –** A number of gram-positive bacteria can form a special resistant, dormant structure called an endospore. Endospores develop within vegetative bacterial cells and are extraordinarily resistant to environmental stresses such as heat, ultraviolet radiation, gamma radiation, chemical disinfectants, and desiccation.

- **Eukaryotic Cell**

In Eukaryotic cell genetic material is organized in a double membrane bound nucleus while cytoplasm contains a number of membrane-bound organelles. Cells are eukaryotic in protista, fungi, plantae and animal kingdom.

(A) Cell Wall

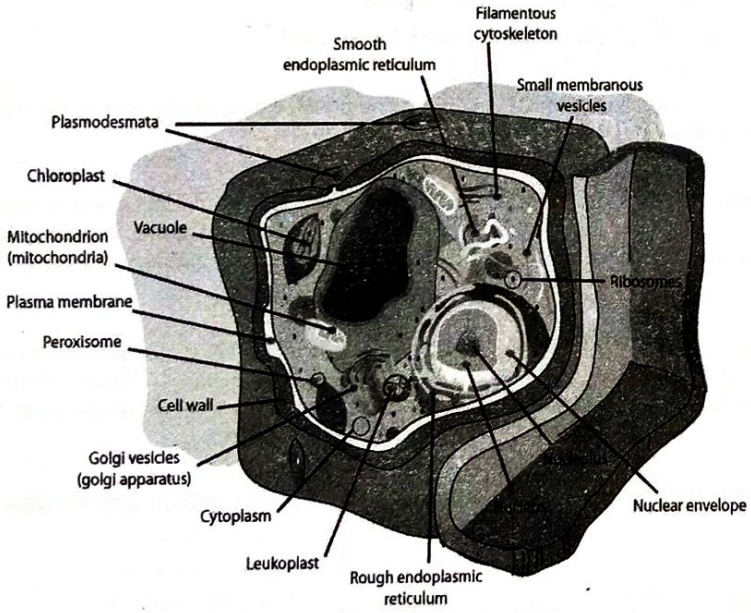
It is the outer rigid, protective, permeable non-living covering of plant cells (cellulose and pectin), fungal cells (chitin) and prokaryotes (murein) but not present in gymnogametes, L-phase bacteria and mycoplasma. Cell wall not only gives shape to cell and protect cell from mechanical damage and infection, it also helps in cell to cell interaction and provides barriers to undesirable macromolecules.

Component of Cell wall: It has two parts, gel-like matrix and fine fibrils called microfibrils. Cell wall was earlier considered as dead. Now it is regarded as partially living because it is capable to grow, metabolically active and cell cannot live without its wall.

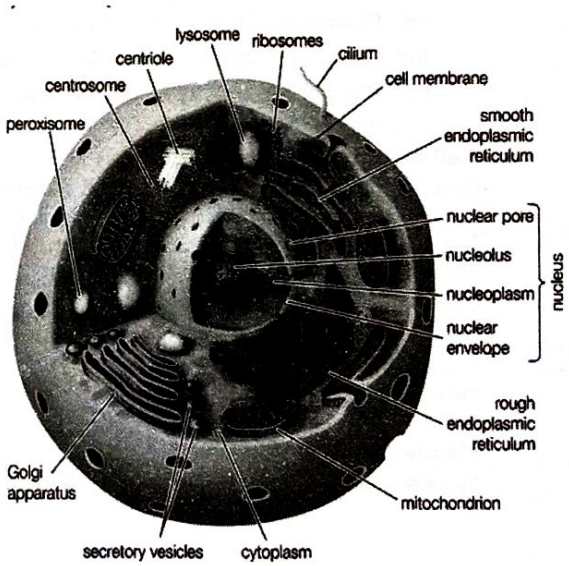
Structure of Cell wall: Microfibrils, pectic substances and proteins of the cell wall form independent networks. Microfibrils form 20-40% of cell wall. They form first network and remains joined with hemicellulose. Pectin form second network. It is also connected with hemicelluloses.

Important-

6000 glucose joined by β1→ 4 to form a cellulose, 100 cellulose form a Micelle and 20 Micelle form a microfibril. Micelle is smallest structural unit of cell wall. Pectin is a mixture of galacturonic acid and sugars. Lignin is formed of coniferyl alcohols. It reduces hydration and increases hardness of wall.



Plant Cell



Animal Cell

Layers of Cell wall

(i) Middle lamella: Outermost part of cell wall made up of calcium- magnesium- pectate, also called common cementing layer between two cells. On ripening, fruit softening is due to dissolution of pectin of middle lamella.

(ii) Primary wall: It is thin, elastic, first wall layer. It has short microfibrils, forming a loose and wavy network. Well developed in young cell but diminishes on maturation. On dry weight basis cellulose content is low (20%) but hemicellulose (50%) is high.

(iii) Secondary wall: It is thick, inelastic and has closely arranged straight and parallel microfibrils. Cellulose is high (20-40%). Hemicellulose content is 25%. Less developed in young cell but develops on maturation.

Deposition of Cell wall

It is found in secondary wall. It may be lignin (e.g., wood or xylem), cutin (e.g., epidermis), suberin (cork, endodermis)

Structures of Cell wall

(i) Plasmodesmata: Cytoplasmic criss –cross bridges between adjacent cell. They have fine canal lined by plasma membrane, called desmotubule (E.R. tubule).

Plasmodesmata produce a continuum of living material called symplasm. Cell walls and intercellular spaces constitute a nonliving component of plant body known as apoplasm.

(ii) Pits: Pits are depressions in the secondary walls. Pits of two adjacent cells generally lie exactly opposite and form pit pairs or complete pit. A pit of wall of free surface cell will be without a partner, called blind pit. Pit has two parts— pit or closing membrane and pit cavity/chamber with a aperture on surface of wall. Pit membrane has primary wall + middle lamella + primary wall of adjacent cell. Apoplasm transport may occur from pits.

Pit has two parts — pit or closing membrane and pit cavity/chamber with a aperture on surface of wall.

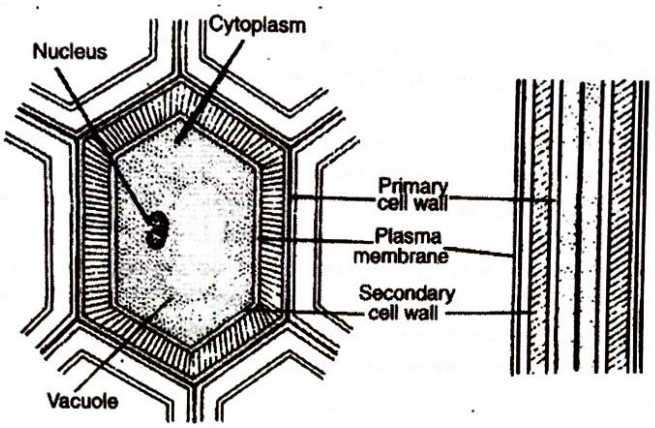


Fig. Structure of the cell wall

Function of cell wall

(i) It provides definite shape and rigidity to cell.

(ii) The system of adjacent cell walls throughout the plant body constitute the apoplast.

(iii) Plasmodesmata in cell wall form a system of interconnected protoplasts called the symplast.

(iv) Cutin and Suberin deposits check water loss.

(v) Phycocolloids (water holding substances) are extracted from the cell wall of marine algae, e.g., algin (brown algae), agar (red algae) and carrageen (red algae) are used commercially.

(B) Cell Membrane \ Plasmalemma

Outer most covering of animal cell and second covering in plant cell. It occur around protoplast and organelles as well as inside some organelles (thylakoids in chloroplasts) in eukaryotic cell. Term cell membrane was given by Nageli & Cramer in animal cell. But in plant cell, it was reported by Mirbel. Term plasmalemma or plasma membrane by Plowe. Biomembrane by Singer & Nicholson but unit membrane by Robertson.

Composition of Plasmembrane

Cell membranes possess lipid, protein and carbohydrate. The ratio of protein and lipid varies considerably in different cell types. In human beings, the membrane of the erythrocyte has approximately 52 percent protein and 40 percent lipids. Under electron microscope, a membrane appears trilaminar/tripartite with a middle electron transparent layer and an electron dense layer on either side.

Membrane Organization

(i) Lamellar or Sandwich Models (Danielli and Davson Model)-Cell membranes have both protein and lipids in distinct layers.

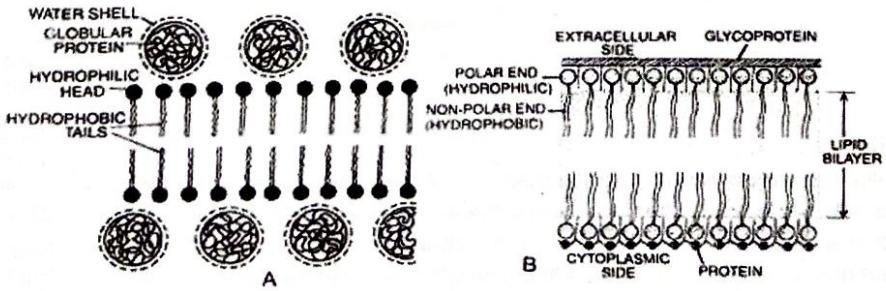
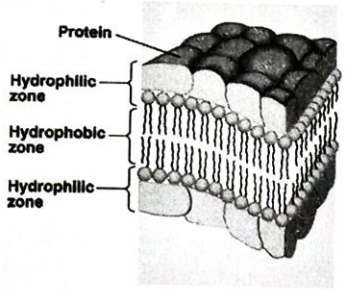
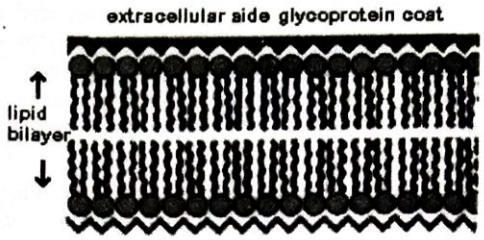


Fig. Lamellar models of plasma membrane, A. After Danielli and Davson (1935), B. Unit membrane, after Robertson (1959)

A double phospholipid layer is surrounded on either side by a layer of hydrated Globular proteins or P-L-L-P. The hydrophobic or nonpolar tails of the two lipids layers are towards the center and hydrophilic head towards outer surface.



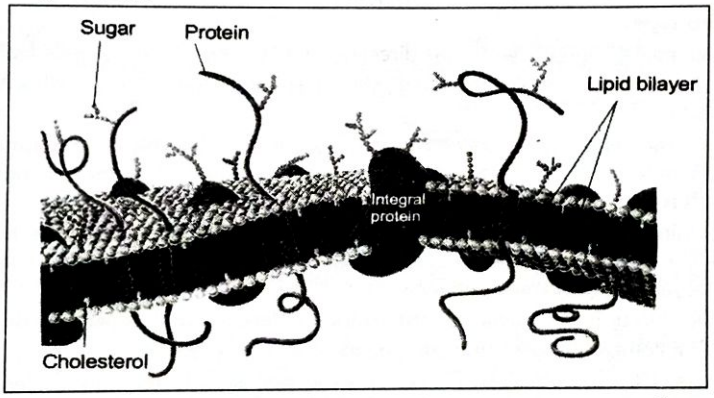


(ii) Robertson's Model (Robertson): A lipid bilayer is surrounded on either side by extended or β-protein.

(iii) Fluids Mosaic Model (Singer & Nicolson, 1972): Membranes are quasifluid with a viscous lipid bilayer having proteins at places (mosaic) both on surface and inside, also called as "protein icebergs in sea of lipids." and gulab jamun model. Quasifluid nature of lipid enables lateral movement of proteins within the overall bilayer. This ability to move within the membrane is measured as it's fluidity.

Fluid nature of membrane is also important from the point of view of function like cell growth, formation of intercellular junctions, secretions, endocytosis, cell division etc.

Lipid: Lipid is basic structural frame work providing fluidity, stability, elasticity due to nonpolar tails. Lipids are generally phospholipids with one polar hydrophilic heads and two nonpolar hydrophobic tails of saturated hydrocarbons (amphipathic or amphiatic by Hertley).



Proteins: Proteins are globular. They may be structural, enzymatic, carrier, permease and receptor. They are of two types- Intrinsic and extrinsic (cell surface markers).

(i) Extrinsic/External/ peripheral protein (30% of total): Superficial and less embedded in lipid and can be easily separable (non-covalently attached to Intrinsic protein) or cannot be easily separable (covalently attached to lipid).

(ii) Intrinsic/Internal/integral protein (70% of total): Deeply embedded in lipid layer and cannot be easily separable. Some protein remains across the lipid called tunnel protein. Proteins extending from outside to inside are called tunnel proteins or transmembrane proteins (e.g., glycophorins). They act as channels for passage of water, ions, solutes.

Glycocalyx (cell coat):

Oligosaccharides (negatively charged) covalently attached to both lipids and protein on outer surface of the membrane producing glycolipids and glycoproteins respectively, called glycocalyx. They make the cell membrane, asymmetric. It helps in recognition, attachment and antigenic properties.

Membrane Transport-

It is selectively or differentially permeable across which lipid soluble neutral molecule pass but water-soluble polar solute cannot pass through plasma membrane. A few ions or molecules can pass through by active transport against the gradient. Occurs by 4 methods—passive, facilitated, active & bulk.

(i) Passive Transport: No energy is spent, no enzyme is used. Occurs along concentration gradient e.g.diffusion, osmosis.

(ii) Facilitated Transport or Facilitated Diffusion:Passage of substances along the concentration gradient without expenditure of energy that occurs with the help of permeases. e.g. Transport of sugars, amino acids and nucleotides.

(iii) Active Transport: Occurs with help of energy and usually against concentration gradient. For it, membrane has carriers and gated channel.

Carriers-They are integral protein, like lecithin. e.g. Transport of sugar, amino acid & nucleotide.Gated Channels- These are called pumps, e.g., H^+ pump, K^+ pump, Cl^- pump, Na^+ - K^+ pump.

(iv) Bulk Transport: Transport of large quantities of molecules and food particles. In it formation of transport or carrier vesicles occurs, It is of two types. Endocytosis and exocytocis.

Important-

Only active transport can produce concentration gradient while passive and facilitated transport removes the gradient.

Function of Plasmalemma

(i) It separates the contents of the cell from its outside environment and it regulates what enters and exits the cell.

(ii) Plasma membrane plays a vital role in protecting the integrity of the interior of the cell by allowing only selected substances into the cell and keeping other substances out.

(iii) It also serves as a base of attachment for the cytoskeleton in some organisms and the cell wall in others. Thus the cell membrane supports the cell and helps in maintaining the shape of the cell.

(iv) The cell membrane is primarily composed of proteins and lipids. While lipids help to give membranes their flexibility and proteins monitor and maintain the cell's chemical climate and assist in the transfer of molecules across the membrane.

(v) The lipid bilayer is semi-permeable, which allows only selected molecules to diffuse across the membrane.

(C) Protoplasm

It is a Polyphasic crystallo-colloidal living matter of cell (Fischer) that contains all the properties of life. Term protoplasm was coined by Purkinje. Huxley called it physical basis of life. New Protoplasm develops inside the older one, capable of growth and division.It is sensitive to different stimuli. pH lies between 6.5 — 7.0. Protoplasm generally shows cyclosis but the same is absent in prokaryotes. Particle shows brownian movement.

Composition of Protoplasm- It has Approx. 5000 compounds so called mixture of mixtures or super mixture. Out of them water is most abundant. It has major six elements (CHONSP=99%) and big four elements (CHON=94%) out of them O is most abundant element (60%).

Protoplast-It is a unit mass of protoplasm present in a plant cell (without wall). Termed by Hanstein. In mature plant cells, It is peripheral around a central vacuole and called primordial utricle.

Cytoplasm (Strasburger)

Protoplasm excluding nucleus. It is differentiated into cytoplasmic matrix, cell organelles (organoides) and cell inclusions. It is main arena of cellular activity. Matrix is differentiated into outer thick gel part is ectoplast (plasmagel) and inner thin sol part is endoplast (plasmasol). Endoplast shows cyclosis/ cytoplasmic streaming (Amici in Chara).

Cyclosis is of two types:

Rotation: Cytoplasm continuously flows in one direction (e.g., young cells of Hydrilla leaf).

Circulation: Matrix flows in different directions (e.g., staminal hair of Tradescantia = Rhoea).

(D) Vacuoles

It is noncytoplasmic sac, which is separated from cytoplasm by a tonoplast membrane (40-50 Å). Mature plant cell has large single vacuole (90% of total cell volume) while young has many small. It is absent in animal cell, if present then small and many. It arise from SER. It is four types.

Sap Vacuoles: Contains sap or water with dissolved inorganic and organic substances. It maintains osmotic pressure, osmosis and stores useful as well as waste substances (waste deposit bin). Cell sap is slightly acidic (malic acid) and hypertonic due to storage of K^+. It has anthocyanin, betacyanine pigments.

Contractile Vacuoles: Occur in fresh water protist (Amoeba, Paramecium). It perform osmoregulation and excretion.

Food Vacuoles: It is a complex of lysosome and phagosome and causes digestion.

Gas or Air Vacuoles (Pseudo vacuoles): Found in some prokaryotes and surrounded by a thin protein membrane. It stores metabolic gases and take part in buoyancy regulation.

(E) Plastids

It is double membranous, semiautonomous cell organelles, which occur in all plants and some euglena, can easily observed under microscope as they are very large. All plastids formed from Proplastid or Eoplast (colourless precursors). They are self replicating, have naked DNA, 70 S ribosomes and lamellae. They are largest cell organelles (smaller only to nucleus = largest component of cell).

Plastids are of three main types (Schimper) — Leucoplasts, Chromoplasts and Chloroplasts. All are interchangeable due presence of similar basic structure.

(i) Leucoplasts: Colourless plastids, occur in nongreen plant cells and of three types
Amyloplasts: Storage of starch.
Aleuroplasts or Proteinoplasts: Storage of proteins,
Elaioplasts (Oleosomes): Storage of fats.

(ii) Chromoplasts: Coloured other than green due to presence of carotenoids (fat soluble).

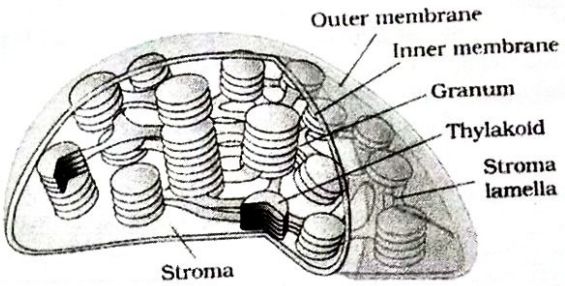
(iii) Chloroplasts (Schimper; Autoplasts by Meyer, Kitchen of cell): Double membranous, photosynthetic green plastids, storing starch (assimilatory). 20-40 Chloroplasts present in each mesophyll cell but only one in chlamydomonas.
Shapes of chloroplast: In higher plants, it is mostly lens-shaped or discoidal. Cup-shaped: Chlorella, Chlamydomonas. Girdle-shaped: Ulothrix. Spiral-shaped/scalariform: Sprogyra.

Size of chloroplast : 5 – 10μm long and 2 – 4 μm broad

Inner membrane is parallel to outer membrane. It is folded inward to form lamellae. Internally, the chloroplast contains matrix or stroma and thylakoids or photosynthetic lamellae. Thylakoids (By Menke) are membrane-lined flattened sacs called structural unit of chloroplasts.

Stacks of thylakoids form granum. A chloroplast has 40-60 grana. A granum has 10-100 thylakoids. Space present in a granal thylakoid is called
loculus or lumen while that of stromal thylakoids is termed as fretz channel. Photosynthetic pigments are located in membrane of thylakoid in specific areas called quantasomes. Quantasome has 230 chlorophyll (160 a + 70 b) and 50 carotenoid molecules. Thylakoid is third membrane of chloroplast. It is analogous to cristae of mitochondria Matrix has

circular naked DNA, RNA, 70S ribosomes, starch grains, enzymes of Calvin cycle and carbohydrate synthesis. Due to presence of DNA, RNA, 70S ribosomes Chloroplast is called semi-autonomous organelle or cell with in cell or endosymbiont of cell or bacterial in origin. Rubisco (ribulose bisphosphate carboxylase, RuBP or RuDP) is most abundant enzyme (protein) in world.



Functions of Plastids

They provide colour to fruits and flowers.

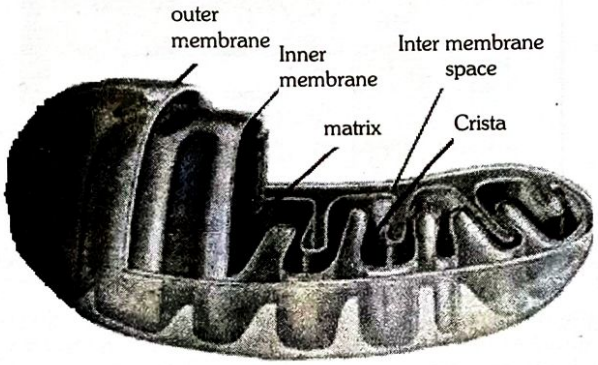
They helps in storage of proteins, starch and oil.

They trap solar energy to manufacture food through the process of photosynthesis.

They help in maintaining balance between carbon dioxide and oxygen during photosynthesis.

(F) Mitochondria

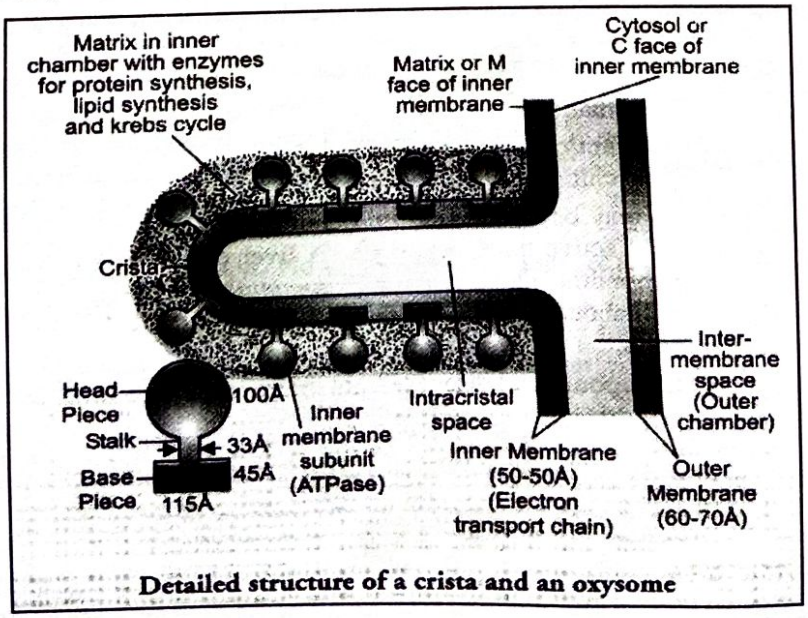
Discovered by Kolliker as Sarcosomes in striated muscles of insects. It was called as Mitochondria by Benda, Fila by Flemming and Bioblasts by Altman. Mitochondria is not easily visible in unstained cell.It is stained with the help of Janus Green (a redox dye) (mitochondria turned greenish blue). Mitochondria involves in aerobic respiration to produce ATP, so called as power houses of cell ,absent in anaerobic cells like red blood corpuscles. A single mitochondrion occurs in yeast, Microasterias, *Trypanosoma* and *Chlorella*. and 500,000 in flight muscle cells.



It is largest (1-4 μm long & 0.5μm broad) cell organelles in animal cells and second largest in green plant cells. Outer membrane is permeable due to porin protein. Inner membrane is selectively permeable. Both separated by P. M.S. Inner membrane is folded to form cristae = structural unit (by Palade).

Inner membrane and cristae have oxysomes/ elementary particle / F_0-F_1 particle / ETP/ Fernandes-Moran particle (10^4—10^5) at interval of 10 nm. They have electron transport chain. ETP forms ATP (by oxidative phosphorylation). So called, functional units of mitochondria. Inner chamber or matrix of mitochondria has one circular, naked DNA, few RNA, ribosome (70 S), manganese and enzymes of Krebs cycle. They are semi-autonomous organelle or cell within cell or endosymbiont of cell or bacterial in origin. The mitochondria divide by fission.

Enzyme of Mitochondria -10% of total cell enzyme (about 70) found in it. They are oxidative (catabolic/Respiratory). Both membrane have their own enzymes. All enzymes of Kreb's cycle present in matrix except succinic dehydrogenase.



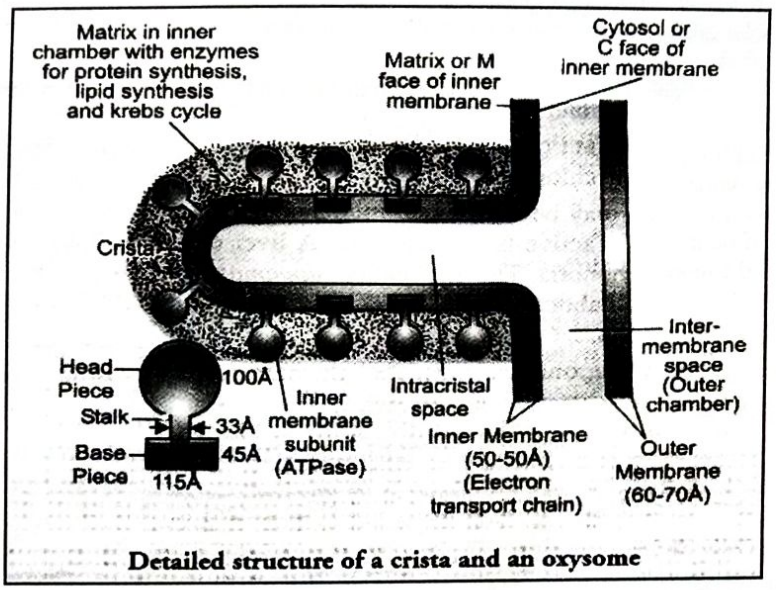
Detailed structure of a crista and an oxysome

Important-

In the inactive or orthodox state the outer chamber is narrow, while matrix occupies larger area. Respiratory chain is unoperative and ATP concentration is low. In the active or condensed state, the outer chamber is wide and cristae most randomly distributed. Respiratory chain and oxidative phosphorylation are operative.

Functions of mitochondria

The most important function of the mitochondria is to produce energy. The simpler molecules of nutrition are sent to the mitochondria to be processed and to produce charged molecules. These charged molecules combine with oxygen and produce ATP molecules. This process is known as oxidative phosphorylation. Mitochondria help the cells to maintain proper concentration of calcium ions within the compartments of the cell.



Detailed structure of a crista and an oxysome

The mitochondria also help in building certain parts of blood and hormones like testosterone and estrogen. The liver cells mitochondria have enzymes that detoxify ammonia. The mitochondria also play important role in the process of apoptosis or programmed cell death. Abnormal death of cells due to the dysfunction of mitochondria can affect the function of organ.

Endomembranous System

While each of the membranous organelles is distinct in terms of its structure and function, many of these are considered together as an endomembrane system because their functions are coordinates. The endomembrane system includes endoplasmic reticulum (ER), golgi complex, lysosomes and vacuoles. Since the functions of the mitochondria, chloroplast and peroxisomes are not coordinated with the above components; these are not considered as part of the endomembrane system.

(G) Endoplasmic Reticulum (Canalicular System)

E.R. or EPR was discovered by Porter in liver cell of rat. Name endoplasmic reticulum was given by Porter. E.R. divide intracellular space into two component luminal (inside ER) and extra luminal (cytoplasm). Broken pieces of ER called microsome (Claude). E.R. is a system of membrane lined channel arising from nuclear membrane found in all eukaryotic cells except mature RBC. It forms more than 30-60% of total cell membranes or endomembranous system of cell.

ER + GB + Lysosome +vacuole = endomembranous system = circulatory system of cell.

Components of E.R.

(i) cisternae (parallel interconnected flat plates).

(ii) tubules (branched tubular network).

(iii) vesicles (round).

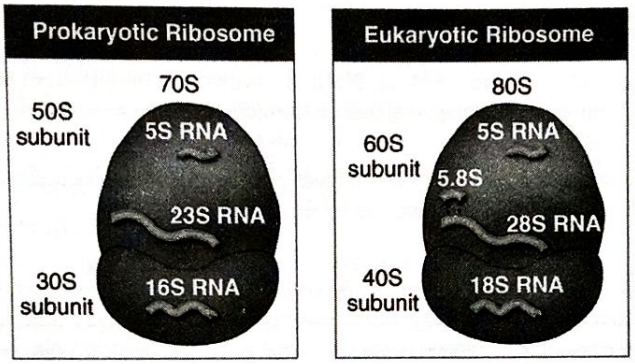
Types of ER: (1/3 SER + 2/3 RER)

(i) RER/Rough/Granular ER (Basophilic nature)-It bears ribosomes. It is abundant in actively secreting cells. Ribosome binds to ER through 60 S subunit with the help of glycoprotein (ribophorin). It has more of cisternae.

(ii) SER/Smooth/Agranular (Acidophilic Nature)-It is without ribosomes and found in cells which producing large quantity of lipids. It arises from RER. SER has more tubules and vesicles. It forms vitamin C, carbohydrates, spherosomes, Glyoxisome, GB, Vacuole, lipid like steroidal hormone in animal. Detoxification of toxins, pollutants, carcinogens and drugs is carried out by P-450 and P-448 found on S.E.R. of liver cells and mitochondria.

(H) Ribosomes

These are submicroscopic naked granular nucleoprotein organelles. Palade discovered in animal cells in 1953 and gave the name. These are also present in mitochondria and chloroplast so also called organelle within organelle. These are smallest and most abundant organelle. They are also called as Protein Factories, Palade Granules. These were discovered after EM and detailed studied by EM + ultracentrifugation.



Structure of ribosome- On the basis of sedimentation coefficient, larger and smaller subunits is respectively 60 S and 40 S (80S), 50 S and 30 S (70S). (S= 10^{-13} seconds), 'S' is direct measure of density and size.

80 S ribosomes are 340 Å with a weight of 4.2 million Dalton.

70 S ribosomes are 290 Å with a weight of 3.0 million Dalton.

rRNA : protein in 80 S ribosomes is (40 : 60) but reverse is true for 70 S ribosomes (60 : 40).

Mg++ ion is essential for binding the ribosome subunits. Value is 1-2 mM for 80S and 0.5 mM for 70S. Subunits separate below this concentration. They form dimer, when Mg2+ concentration is higher. 6-8 Ribosomes may occur in group on mRNA called polyribosome/ergasome/polysome (by Rich).

Proteins of all ribosomes are similar but rRNA differs from ribosome to ribosome.

Types of Ribosome- Found in both prokaryotes and eukaryotes. In eukaryotes, they are of two types, cytoplasmic & organelle ribosome. Organelle ribosomes are 70 S (in mitochondria and plastids). Cytoplasmic ribosomes of are 80 S. 80 S may occur freely or attached to E.R. Prokaryotes has only free cytoplasmic ribosomes are 70 S.

Functions of Ribosome

They assemble amino acids to form specific proteins, proteins are essential to carry out cellular activities.

The process of production of proteins, the deoxyribonucleic acid produces mRNA by the process of DNA transcription.

The genetic message from the mRNA is translated into proteins during DNA translation.

The sequences of protein assembly during protein synthesis are specified in the mRNA.

The mRNA is synthesized in the nucleus and is transported to the cytoplasm for further process of protein synthesis.

In the cytoplasm, the two subunits of ribosomes are bound around the polymers of mRNA; proteins are then synthesized with the help of transfer RNA.

The proteins that are synthesized by the ribosomes present in the cytoplasm are used in the cytoplasm itself. The proteins produced by the bound ribosomes are transported outside the cell.

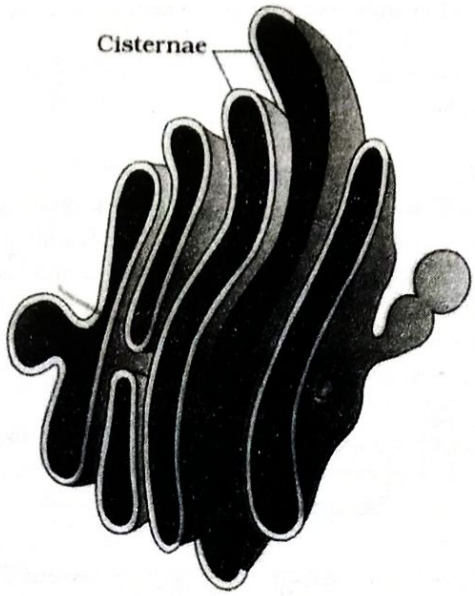
(I) Golgi Complex

It is complex organelle made of membrane-lined stack of cisternae, network of tubules, vesicles and vacuoles which was first seen by George but studied by Golgi in nerve cells of Owl and Cat in 1898. GB is present in all eukaryotic cells except RBC, sieve tube, prokaryote and sperm. A unit of Golgi apparatus is called Golgisome. In plant cells, Golgi apparatus has many isolated units called dictyosomes while in animal cells it occurs as single complex called golgi complex. Golgi apparatus is surrounded by a clear zone of exclusion (Morre) in which ribosomes, mitochondria, plastids, storage granules, etc. are absent but SER may present.

Component of GB

GB is made up of - (i) Sacculus or Cisternae (0.5-1.0 μ m diameter) (ii) Tubules (iii) Vesicles (iv) Vacuoles.

GB has a central stack of 3—10 inter-connected curved but parallel membrane-lined narrow sacs (cisternae).



(i) Convex forming face/cis-face (towards EM or NM): It receives materials from endoplasmic reticulum (GER = Golgi associated E.R.) in the form of transitional vesicles or forming vesicle. Transitional vesicles fuse with the cisterna of convex forming face.

(ii) Concave maturing face/trans face (towards PM): It gives out large golgian vacuoles and small vesicles (smooth or secretory vesicles and coated vesicle) having transformed materials.

Functions of GB

It synthesizes glycoprotein & glycolipid with help of glycosyl transferase. It takes part in secretion of a number of products, galactose, zymogen, glycoproteins (e.g., mucilage from root cap cells), hormones, melanin, matrix of connective tissue, middle lamella, acrosome and lysosomes (from golgian vacuoles), root hairs, acrosome, yolk, cell wall material (pectin, hemicellulose, polysaccharide but not cellulose).

Golgi apparatus modified materials for secretion in the form of smooth or secretory vesicles (Biochemicals flow) e.g. hormone, proenzyme, nasal, tears, saliva. Membranes flow occurs in form of coated vesicles (transformation or recycling of membranes.) G.B. helps in packaging of materials to be delivered either intracellular targets or secreted out side.

(J) Lysosomes

Smallest single membranous organelle having acid hydrolyzing enzymes. They were discovered by Duve as pericanalicular body in rat liver but under electron microscope observed by Novikoff (named lysosome).Other names: Suicidal bag, Disposal unit, Atom bomb, Demolition squad, Scavenger of cell, Recycling center, Cellular house keepers. They are formed by G.B. and have about 40 types of acid hydrolases enzymes for digestion of all materials except cellulose. All the enzymes are not present in the same lysosome. Acidic pH (5 pH) inside lysosomes is maintained by pumping protons into them by H+pump. They are most abundant in phagocytic cells (WBC).

Lysosomes are of four type (show polymorphism)

(i) Primary lysosome (Protolysosomes /Storage granules): Arises from GERL, has inactive enzyme

(ii) Heterolysosome (digestive vacuoles/ heterophagosomes = primary lysosome + phagosome): Forms when primary lysosome combines with extra cellular material or foreign body.

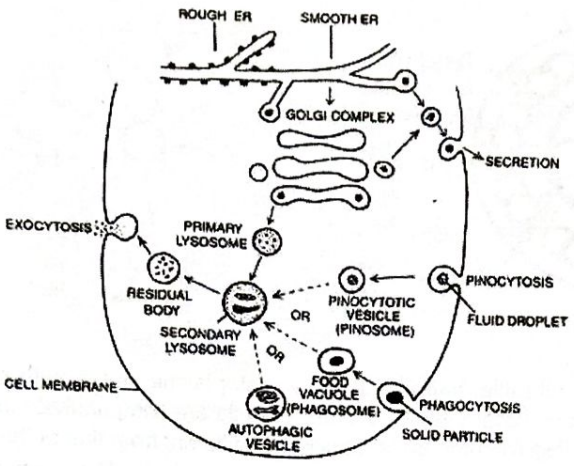
(iii) Autophagic vacuoles (Autophagosome, Autolysosome, Cytolysosome): It is formed by the fusion of many primary lysosome to isolation envelope of dead organelle. Degenerated part first covered by isolation envelop before autophagy. These digest the degenerate and useless parts cell itself called autophagy/postmortem degeneration. Some time they causes destruction cell itself on burst called autolysis of cell. So called as suicidal bag of cell.

(iv) Residual body (Tertiary lysosome or Telolysosome): Autophagosome and hetrolysosomes having undigested materials called Residual body. These undergo ephagy or exocytosis.

Digestive vacuole, autophagic vacuoles & residual body are together called secondary lysosomes. In plant cell sphaerosome, vacuole and alurone grain shows lysosomal activity.

Functions of Lysosome:

- Starts the cell division so called trigger of cell division
- Remodeling of bones during osteogenesis (Extracellular digestion)
- Digestion of extra cellular material called heterophagy (Intracellular digestion)
- Digestion of dead cell organelle called Autophagy (Intracellular digestion) called
- Disposal bag or recycling center. These forms second line of defense of body.
- It forms acrosome, so helps in fertilization (Extracellular digestion).



Types of lysosomes and their functions.

Single membranous organelles, which take part in direct oxidation (other than respiration). They are of 2 types — peroxisomes & glyoxisomes.

(K) Peroxisomes (Uricosome by De Duve)

They have enzymes for peroxide biosynthesis and break down. H_2O_2 producing enzyme: Peroxidase, urate oxidase, amino acid oxidase, hydroxy acid oxidase. Peroxide destroying enzyme: Catalase. They take part in oxidation of extra biochemicals like purines, amino acids, alcohol. In mesophyll green cells, peroxisomes interact with chloroplasts and mitochondria to take part in photorespiration or glycolate cycle or C-2 cycle (Tolbert). For this they have glycolate oxidase and transaminase.

(L) Glyoxisomes/Glyoxysomes (Breidenbach)

Found only in fat rich plant cells where they take part in β-oxidation of fats and perform glyoxylate cycle/ modified Kreb cycle (fat is converted into carbohydrate by gluconeogenesis).

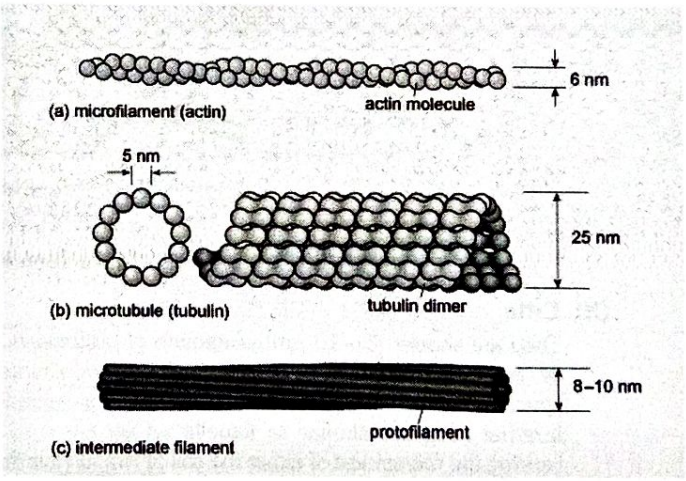
Fibrous or fine tubular structures, which form supportive structures of cell and helps in motility and maintenance of shape of cell are called Cytoskeletal Structures. They are of three types— microtubules, microfilaments, intermediate fibers

(M) Microfilaments (Paleviz)

Double helical solid rods of actin and myosin with 5-8 μ m diameter. They are found in muscular & non muscular animal cell. They are most prominent in muscle, called myofilaments.

(N) Microtubules

Discovered by DeRobertis and Franchi in nerve axons and named as neurotubules. Term microtubule was coined by Slautterback. They are unbranched hollow tubules of indefinite length, 25 nm of thickness with boundary formed of 13 helically arranged protofilaments of α and β-tubulins (so also called hetrodimer). Microtubule has +ve (polymerizing) and –ve (depolymerizing) ends, so it has polarity. Microtubules grow from nucleating regions/MTOC (microtubule organization centre). Their tips can grow and shorten quickly. GTP, Ca^{2+}, Mg^{2+} and a calmodulin bound protein are required for assembly. Colchicine prevents assembly (called mitotic poison).They provide polarity to cell and form spindle, centrioles, basal bodies, cilia and flagella. They help in cytoplasm streaming, amoeboid movements, sol—gel changes, and cleavage.



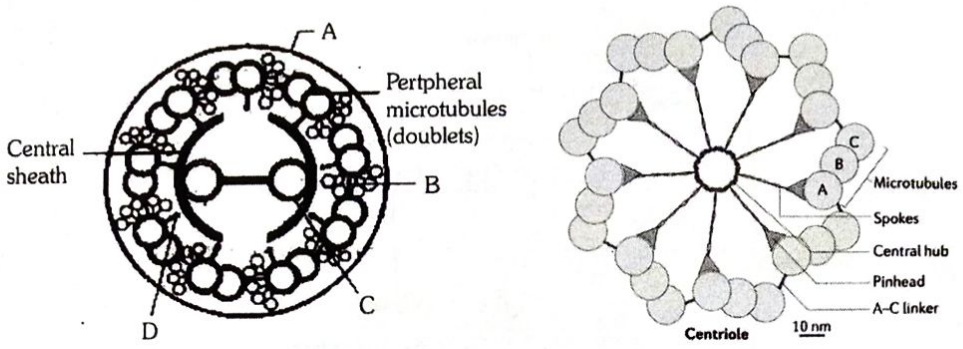
(O) Intermediate Fibers

They are solid, unbranched fibrils of noncontractile protein.

(P) Centrosome

It is non-membranous minute (0.15 μm diameter) organelle. It occurs in pair (diplosome) inside a specialized cytoplasm called centrosphere or kinoplasm. Complex is called centrosome or central apparatus or cytocenter. Two centrioles present at right angles to each other. It is surrounded by zone of exclusion. Centriole can replicate in S phase but has no DNA It is characteristic feature of animal cell. Amongst protists, fungi and metaphytes they are found in ciliated and flagellated cells. Each centriole has a cartwheel like structure. There are nine parallel, peripheral triplet fibrils of tubulin (9 + 0) tilted at 40° angle. Three subfibres of triplet from outside to inside are C, B & A.

B- subfibre has 13 protofilaments like a microtubule but C and A subfibres share 2—3 protofilaments with B-subfibre. Adjacent triplets are interconnected by proteinaceous C-A linkers. A proteinaceous rod or hub occurs in the centre. Subfibre A of each triplet is connected to hub by a radial proteinaceous strand called spoke. Spokes are also connected to C-A linkers. Centrioles are surrounded by massules or pericentriolar satellites or MTOCs (microtubule organization center) or MTG (microtubule generator) for formation of new centrioles in S phase. Centrosome helps in formation of astral rays and spindle fibers. Centrioles are required to form basal bodies, cilia, flagella and astral spindle poles.



(Q) Flagella

They are 150 μm long, 1 to 4, vibratile, hair-like, narrow protoplasmic out growth present on the free surface of the cell. It has four parts — basal body, rootlets, basal plate and shaft. Flagella are comparatively longer and responsible for cell movement. The prokaryotic bacteria also possess flagella but these are structurally different from that of the eukaryotic flagella.

Basal Bodies (Basal body, basal granule, kinetosome or blepharoplast): These are microcylinders at base of flagella and cilia. They lie below the plasmalemma. Structure is similar to a centriole with 9 + 0 cartwheel structure in the proximal region.

Basal plate: Dense plate-like band that lies between basal body and shaft of a cilium or flagellum.

Shaft: It has a covering of plasmalemma, a matrix and an axoneme. Axoneme has nine peripheral doublet fibrils, two central singlet fibrils, linkers and spokes. (9+2 arrangement). Peripheral doublet fibrils are tilted at an angle of 10°. Peripheral doublet fibril has a slightly broader outer subfibre B and slightly narrow inner subfibre A. They are made of microtubules. A has two bent arms, outer with a hook. A double proteinaceous bridge occurs between singlet central fibrils (C1 and C2). Adjacent doublet fibrils are connected by proteinaceous B—A linkers. The central fibrils and side arms of subfibre A are made of dynein protein with ATP-ase activity. B—A linkers and radial spokes are made of protein nexin. Flagella with hair like flimmers, called tinsel flagella and without flimmers are called whiplash flagella.

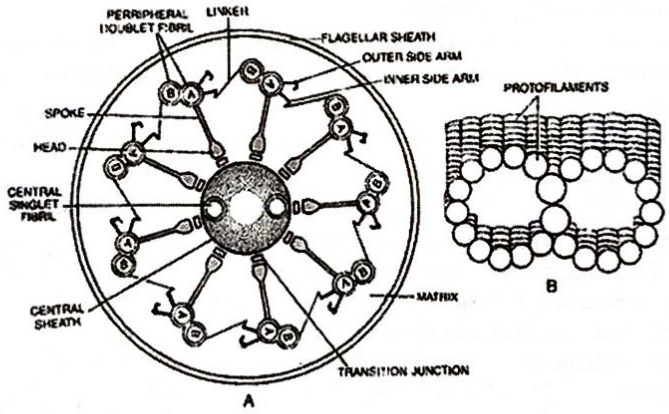
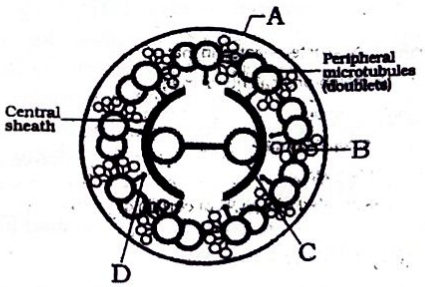


Fig : A. Ultrastructure of Flagellum in cross section. B. Doublet fibril without arms.

(R) Cilia

They are shorter (5—10 μm) outgrowth of protoplasm, more numerous have sweeping or pendular movement and beat in a coordinated rhythmic movement either synchronous (isochronous, simultaneous) or metachronous (one after the other). Internal structure similar to flagella. Cilia are small structure which work like oars, causing the movement of either the cell or the surrounding fluid.



(S) Nucleus

Discovered by R. Brown in Orchid root as Areola in 1831 and named by him. It is a double membranous protoplasmic body. Material of nucleus is stained by basic dye (acetocarmine) by Fleming and named chromatin. Cell usually has single nucleus (uninucleate, mono-karyotic). However, binucleate {e.g., Paramecium caudatum) and multinucleate/ polykaryotic forms also occur. Multinucleate form is called syncytium in animal cells (by fusion of cells) and coenocytic in plant cells (due to free nuclear division). Nucleus is absent in some cells like mammalian RBCs, sieve tube (lost secondarily) called anucleated cell. Nucleus is commonly rounded and present in center but in plant cell it present at periphery due to vacuole called primordial utricle. Largest cell component (25 μm diameter = 10-25% of total cell). But 60% in Thymus cell

Nucleocytoplasmic Ratio/ karyoplasmic (Hertwig):

$$\frac{\text{Volume of Nucleus (Nv)}}{\text{Volume of Cytoplasm (Cv)}} = \frac{\text{Volume of Nucleus}}{\text{Volume of cell - Volume of nucleus}}$$

$$\text{Metabolic activity} \propto \text{N P ratio}, \quad \text{N P ratio} \propto \frac{1}{\text{size of cell}}$$

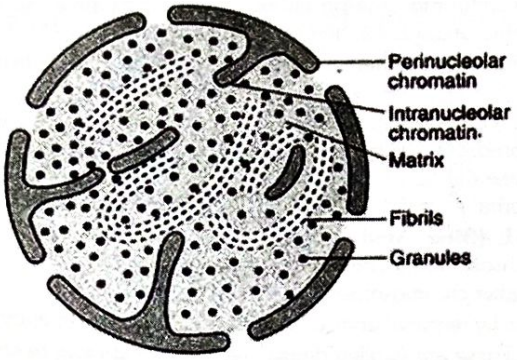


Fig. Ultrastructure of nucleolus (section view)

It has DNA (10%), basic histone proteins (15%), non histone acidic proteins (65%), RNA (5%). It has five parts—Nuclear envelope, Nucleoplasm, Nuclear matrix, Chromatin and Nucleolus.

(i) **Nuclear Envelope (Erclab, Hertwig):** Has two membranes separated by 10—70 nm perinuclear space. Outer may have ribosomes and interconnections with E.R. It has many polygonal pores (1000-10000) with diameter of 200-800 Å. Nucleoplasmin protein of pore facilitate nucleo- cytoplasmic traffic.

(ii) **Nucleoplasm or Nuclear Sap (Strasburger):** Transparent, non staining, liquid with pH 7.2-7.6. It has raw materials for synthesis of DNA and RNA like nucleotide, DNA polymerase, RNA polymerase.

(iii) **Nuclear Matrix (Nuclear skeleton):** It is a network of acidic proteinaceous fibrils which is hard towards periphery to form fibrous lamina or nuclear lamina.

(iv) Chromatin network (Chromatin Reticulum by Flemming): It is a fibrous hereditary material formed by DNA-histone complex. During cell division, it gets condensed in form of chromosome. It is brightly stained with basic dye like Haematoxylin, Acetocarmine. It has DNA—31%, RNA—5%, histone protein—36% and non histone protein—28%. It may-

Euchromatin: It is light stained, transcriptionally active, fast replicating.

Hetrochromatin: It is darkly stained, transcriptionally inactive, slow replicating, heterochromatin (Heitz).

(v) **Nucleolus (Plasmosome):** Discovered by Fontana. It has no membrane and formed at specific spot called nucleolar organizer region or NOR.

It forms ribosome, so called ribosome factory. Normally one nucleolus present per nucleus but number increased during protein synthesis.

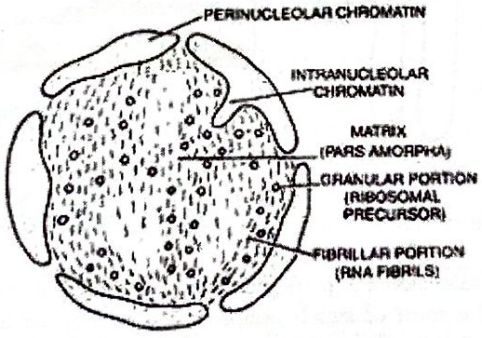
Nucleolus contains four parts

(a) **Amorphous matrix (pars amorpha):** Has protein, Ca^{++}, non-histone protein, RNA polymerase.

(b) **Fibrillar (pars fibrosa or nucleonema):** Precursor of granular part and rich in rRNA+ protein.

(c) **Granular (pars granulosa):** Rich in nucleoprotein and precursor of ribosome.

(d) **Chromatin (pars chromosoma):** It is r-DNA having chromatin.



Chemical Composition -DNA-40%. Histone protein-50%. Non histone Proteins-8.5%. RNA—1.5%. Ca, Mg and Fe.

Ultra-Structure of chromosome

(i) **Pellicle:** It is outer thin sheath of nongenetic material.

(ii) **Matrix:** Non genetic ground substance of chromosome, which has RNA, acid protein and lipid.

(iii) **Chromonema:** It is genetic thread of DNA-histone, which forms the bulk of chromosome.

One chromosome has two coiled chromonemata while at anaphase it has single chromonema. Vertical half of chromosome is called chromatid.

Primary Constriction/Centromere: It is very light stained part of chromosome where two chromatids are attached. Internally centromere has little chromonemal coiling with a small amount of β- heterochromatin. Chromosome also has α-heterochromatin on either side of centromere. It is called kinetochore. Kinetochore has points for attachment of spindle

fibres. Two parts of chromatid/chromosome on either side of centromere are called arms. Metaphase is best to study the morphology of chromosome but anaphase is best for shape.

They may be isobrachial (equal arm) or heterobrachial (unequal arm). Centromeric index is the ratio of lengths of the two arms of chromosomes.

Secondary Constrictions: They are narrow areas. They are of two types, joints and NOR. Joints are areas involved in breaking and fusion of chromosome segments. NOR or nucleolar organizer region is secondary constriction capable of forming nucleolus in interphase due to presence of rDNA. One of the secondary constriction of some somatic chromosome act as NOR (rich in hetrochromatin) eg:13, 14, 15, 20, 21 pair of chromosome of human.

Satellite / Trabant / SAT (Sine Acido Thymonuclinico) : Knob like part, which remains attached with NOR. Chromosome is called sat chromosome (due to poor stainability of NOR). This part has satellite or repeated DNA. SAT-chromosomes are used as marker chromosomes.

Telomeres: They are non sticky terminal ends of chromosome having repetitive DNA

Chromomeres (Pfitzner): These are swollen dense areas on the surface of chromosome. These represent active genes but gene activity can also observed in inter chromomeric regions.

Types of Chromosome-Depending upon number of centromeres, chromosomes are:

(i) **Monocentric:** (one centromere, common type).

(ii) **Dicentric:** (two centromeres, e.g. Zea mays or Maize).

(iii) **Polycentric:** (many centromeres, e.g., germ line chromosome of Parascaris equorum)

(iv) Acentric: (without centromere) or holocentric (whole surface as centromere e.g. spirogyra).

Depending upon position of the centromere, a chromosome can be:

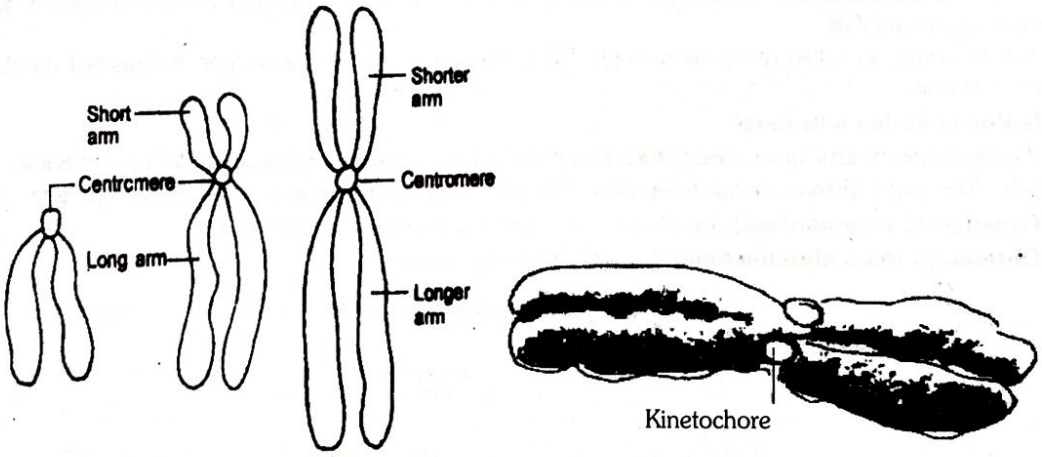
(i) Metacentric: Centromere in middle, anaphasic stage V-shaped.

(ii) Submetacentric: Centromere submedian, anaphasic stage L-shaped.

(iii) Acrocentric: Centromere subterminal, anaphasic stage J-shaped,

(iv) Telocentric: Centromere terminal, anaphasic stage I-shaped.

Karyotype / Idiogram-Description of various aspects of all chromosomes of a cell like number, relative size, position of centromere, length of arms, centromeric ratio, secondary constrictions and satellites. Idiogram is photograph or diagram of karyotype of all metaphasic chromosomes arranged in homologous pairs according to their decreasing length, thickness, position of centromere, length of arms, shape and other characteristics. Sex chromosomes are placed at the end of karyotype except Drosophila (at first position). For obtaining karyotype, somatic cells cultured under aseptic conditions are treated with colchicine (for arresting division at metaphase) and stained.



(T) Cell Inclusions

They are nonliving substances. Due to their presence, a cell may become different from other surrounding cells. It is then called **idioblast**.

(1) **Reserve Food:** It is carbohydrate (starch in plant and glycogen in animal), fat & protein.

(a) **Starch:** It is stored in the form of starch grains inside chloroplast and amyloplast. Starch of chloroplast is called assimilatory while of amyloplast is called storage.

(b) **Protein:** Aleurone grains are storage proteins developed inside aleuroplasts.

(c) **Fat droplet:** Stored inside elaioplast in plant and in adipose tissue in animal.

(2) **Excretory/Secretory Products:** They include mucus, gums, tannins, resins, alkaloids, latex.

8. Cell - The Basic Unit of Life – Multiple Choice Questions

1. Tools and Technique

1. The detailed structure of the membrane was studied after the advent of electron microscope during
(a) 1930's (b) 1950's
(c) 1970's (d) 1990's

2. Which of the following techniques is used to extract proteins from the cell fractionation
(a) Ultracentrifugation (b) Chromatography
(c) Autoradiography (d) Electrophoresis

3. Which of the following dyes is best suited for staining chromosomes
(a) Basic Fuchsin (b) Safranin
(c) Methylene blue (d) Carmine

4. A mixture containing DNA fragments a, b, c, and d with molecular weights of $a+b=c, a>b$ and $d>c$, was subjected to agarose gel electrophoresis. The positions of these fragments from the cathode to anode sides of the gel would be
(a) d, c, a, b (b) a, b, c, d
(c) c, b, a, d (d) b, a, d, c

5. The electron microscope has revealed the presence of

Or

Which among the following can be seen only under an electron microscope [AFMC 1996; MP PMT 1998]
(a) Ribosome (b) Chromosome
(c) Chloroplast (d) Leucoplast

6. With the increase in diameter of the rotor, the effective RCF (relative centrifugal force) at a fixed RPM (revolutions per minute) will
(a) Remain unaffected
(b) Increase
(c) Decrease
(d) Be lower at the bottom of the centrifuge tube

7. Which of the following technique, other than microscopy is used for the study of the cell
(a) Obliteration (b) Plasmolysis
(c) Chromatography (d) Autoradiography

2. Cell Introduction and Cell Theory

1. T. Schwann and M. Schleiden were
(a) Dutch biologists (b) English biologists
(c) Austrian biologists (d) German biologists

2. Difference between the prokaryotic and eukaryotic cells in having
(a) Cell wall (b) Nuclear membrane
(c) Ribosome (d) None of these

3. Which of the following is the exception of cell theory
(a) Bacteria (b) Fungi
(c) Lichen (d) Virus

4. Who proposed the theory that "cells arise only from the pre-existing cells"
(a) Mohl (b) Virchow
(c) Haeckel (d) Brown

5. The branch which deals with the study of cell structure and function is known as
(a) Histology (b) Ecology
(c) Morphology (d) Cytology

6. 'Cell' was discovered by and given the term
(a) Grew (b) Brown
(c) Robert Hooke (d) Darwin

7. The word "Prokaryote" means a cell
(a) With many nuclei (b) With one nucleus
(c) With diffused nucleus (d) Without chloroplast

8. Robert Hooke used the term cell in the year
(a) 1650 (b) 1665
(c) 1865 (d) 1960

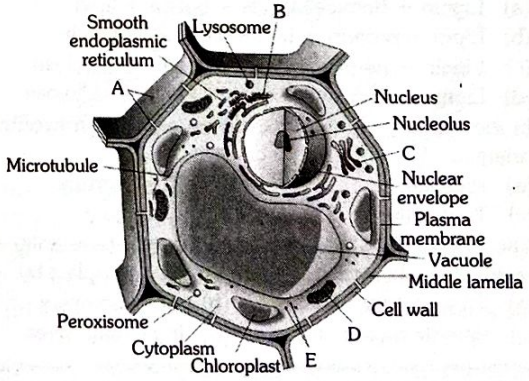
9. Which of the following is absent in prokaryotes
(a) Nuclear membrane (b) Golgi bodies
(c) Endoplasmic reticulum (d) All the above

10. Which of the following forms more than 1/2 of cell
(a) Water (b) Mineral
(c) Protein (d) Carbohydrate

11. Which one of these is not a eukaryote
(a) Euglena (b) Anabena
(c) Spirogyra (d) Agaricus

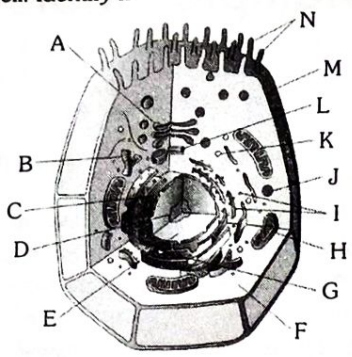
12. Which of the following is not a function of the cytoskeleton in a cell
(a) Intracellular transport
(b) Maintenance of cell shape and structure
(c) Support of the organelle
(d) Cell Motility

13. The given figure shows some of the missing structures in a plant cell (A - E). Identify the marked alphabets



(a) A - Tight junction, B - Rough endoplasmic reticulum, C - Golgi apparatus, D - Mitochondrion, E - Ribosome
(b) A - Plasmodesmata, B - Smooth endoplasmic reticulum, C - Golgi apparatus, D - Mitochondrion, E - Ribosomes
(c) A - Desmosome, B - Rough endoplasmic reticulum, C - Golgi apparatus, D - Mitochondrion, E - Ribosomes
(d) A - Plasmodesmata, B - Rough endoplasmic reticulum, C - Golgi apparatus, D - Mitochondrion, E – Ribosomes

14. The given diagram shows important structures in an animal cell. Identify it



(I) The structure replicates during mitosis and generates the spindle

(II) A major site for synthesis of lipid

(III) Power house of the cell

(IV) Store house of digestive enzyme

(V) Increases the surface area for the absorption of materials

(VI) Site of glycolysis

(VII) The site for active ribosomal RNA synthesis

(a) I - M, II - A, III - H, IV - J, V - N, VI - F, VII - D

(b) I - L, II - B, III - H, IV - J, V - N, VI - F, VII - D

(c) I - D, II - G, III - N, IV - J, V - M, VI - F, VII - A

(d) I - L, II - G, III - H, IV - J, V - D, VI - F, VII – N

3. Cell wall

1. The internal layer joining the primary walls of the two adjacent cells is known as
(a) Plasmodesmata (b) Middle lamella
(c) Periderm (d) Casparian strip

2. Cell wall is absent in
(a) Gametes (b) *Amoeba*
(c) Mycoplasma (d) All of these

3. Plant cell wall consists of
(a) Lignin + hemicelluloses + pectin + lipid
(b) Lipid + protein + hemicelluloses + pectin
(c) Lignin + hemicelluloses + pectin + cellulose
(d) Lignin + hemicelluloses + tubulin + cellulose

4. In the cell walls of the guard cells, cellulose microfibrils are oriented
(a) Radially (b) Transversely
(c) Tangentially (d) Obliquely

5. The chemical substances found most abundantly in the middle lamella is released into the phragmoplast by
(a) Endoplasmic reticulum (b) Golgi complex
(c) Spindle fragments (d) Interzonal fibres

4. Plasma Membrane

1. Which of the following layer is present nearest to the plasma membrane in plant cell
(a) Secondary wall (b) Middle lamella
(c) Primary wall (d) Tonoplast

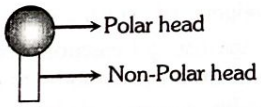
2. Beet root if kept in cold water anthocyanin does not come out due to the plasma membrane
(a) Differentially permeable
(b) Impermeable to anthocyanins
(c) Permeable to anthocyanins
(d) Dead

3. Who proposed "fluid mosaic model" for plasma membrane
(a) C. Cramer and C. Naegeli
(b) Singer and Nicholson
(c) Denielli and Davson
(d) J. D. Robertson

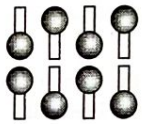
4. Carbohydrates are present in the plasmalemma in the form of
(a) Starch
(b) Cellulose
(c) Hemicellulose
(d) Phospholipids (glycolipids) and phosphoproteins (glycoproteins)

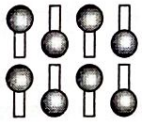
5. Which of the following statements is not true for plasma membrane
(a) It is present in both plant and animal cell
(b) Lipid is present as a bilayer in it
(c) Proteins are presently integrated as well as loosely associated with the lipid bilayer
(d) Carbohydrate is never found in it

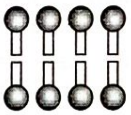
6. In the given figure, the lipid molecules present in the plasma membrane have polar heads and non - polar tails

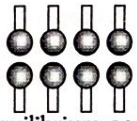


Which of the following figure represents the correct arrangement of lipids in lipids bilayer

(a) 

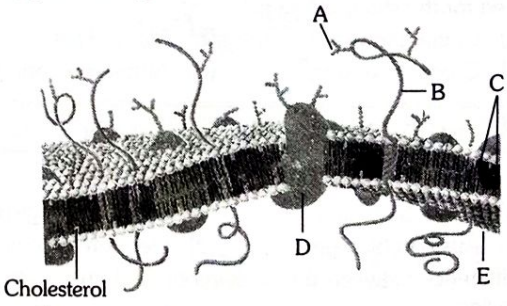
(b) 

(c) 

(d) 

7. On which surface of cell Donnan equilibrium occur
(a) Cell wall (b) Tonoplast
(c) Plasma membrane (d) Nuclear membrane

8. See the given diagram (cell membrane) and identify the components labeled A, B, C, D and E from the list (i) to (vii) given along with



Components :

(i) Sugar (ii) Protein
(iii) Lipid bilayer (iv) Integral protein
(v) Cytopasm (vi) Cell wall
(vii) External protein

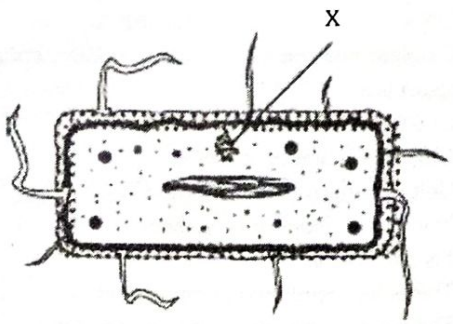
The correct components are
(a) A - (i), B - (ii), C - (iii), D - (vii), E - (v)
(b) A - (i), B - (ii), C (iii), D - (iv), E - (vi)
(c) A - (ii), B - (i), C - (iii), D - (iv), E - (v)
(d) A - (i), B - (ii), C - (iii), D - (iv), E - (v)

5. Protoplasm and Cytoplasm

1. The name 'protoplasm' was given by
   (a) Purkinje (b) Hooke
   (c) A.K. Sharma (d) Schwann
2. Protoplasm is a
   (a) True solution
   (b) Suspension
   (c) Emulsion
   (d) Polyphasic colloidal system
3. Protoplasm was regarded as the "physical basis of life" by
   (a) Huxley (1868) (b) Corti (1772)
   (c) Hardy (1899) (d) Malphighi (1903)

6. Mitochondria

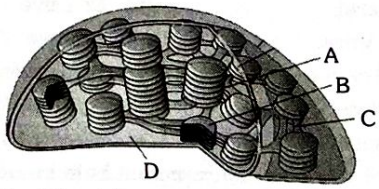
1. Mitochondria perform all of the following functions except
   (a) Nucleic acid synthesis
   (b) β – oxidation of fatty acids
   (c) ATP synthesis
   (d) Polysaccharide degradation
2. The size of mitochondria in a plant cell is
   (a) $0.1-1.0\mu m$ long (b) $1.0-4.0\mu m$ long
   (c) $2.0-4.0\mu m$ long (d) $3.0-4.0\mu m$ long
3. Oxidative enzymes occur mostly in
   (a) Lysosomes (b) Golgi bodies
   (c) Mitochondria (d) Ribosomes
4. Which of the following cell organelle is considered to be rich in catabolic enzymes
   (a) Endoplasmic reticulum (b) Lysosome
   (c) Golgi body (d) Mitochondria
5. A common characteristic feature of plant sieve tube cells and most of the mammalian erythrocytes is
   (a) The absence of mitochondria
   (b) Presence of cell wall
   (c) Presence of hemoglobin
   (d) Absence of nucleus
6. The stain used to visualize mitochondria is
   (a) Fast green (b) Safranin
   (c) Acetocarmine (d) Janus green
7. Some bacterial cells were fixed for microscopic observation. A structure X was observed on most occasions at the cell membrane



In the above diagram, label X represents
   (a) Mesosome (b) Ribosome
   (c) Plasmids (d) Nucleoid

7. Plastids

1. Green pigment (Chlorophyll) present in plants is
   (a) Chromoplast (b) Chloroplast
   (c) Ribosome (d) Lysosome
2. From recent studies, it has been found that pre-existing plastids arise from
   (a) Bodies called proplastids (b) The nucleus
   (c) The vacuole (d) The cell wall
3. Aleuroplasts in a cell store
   (a) Starch (b) Oil
   (c) Protein (d) Nutrients
4. Fat storing granules are
   (a) Elaioplasts (b) Amyloplasts
   (c) Aleuroplasts (d) None of these
5. The thylakoid in chloroplast are arranged as
   (a) Interconnected disc (b) Interconnected sacs
   (c) Stacked discs (d) None of these
6. Extranuclear DNA in the cytoplasm is found inside
   (a) Chloroplast/Mitochondria (b) Ribosome
   (c) Endoplasmic reticulum (d) Golgi apparatus
7. Chloroplast differs from mitochondria on the basis of one of the following features. Mark the right answer
   (a) Presence of two layers of membrane
   (b) Presence of ribosome
   (c) Presence of chlorophyll
   (d) Presence of DNA
8. In higher plants, the shape of the chloroplast is
   (a) Discoid (b) Cup-shaped
   (c) Girdle-shaped (d) Reticulate
9. When green tomatoes fruits turn to red, then
   (a) Chloroplasts are disintegrated and get converted into chromoplasts
   (b) New chromoplasts are formed
   (c) Chromoplasts are changed to chloroplasts
   (d) None of the above
10. Examine the section view of chloroplast showing the different parts



In which of the following options all the four blanks A, B, C, and D are correctly identified
   (a) A – Granum, B – Thylakoid, C - Stroma, D - Stromal lamella
   (b) A – Thylakoid, B – Granum, C - Stromal lamella, D - Stroma
   (c) A – Granum, B – Thylakoid, C - Stromal lamella, D - Stroma
   (d) A – Thylakoid, B – Stromal lamella, C - Stroma, D – Granum

8. Endoplasmic reticulum and Golgi body

1. Dictyosomes are
   (a) Class of ribosomes
   (b) Place of flagellar organelles
   (c) Respiratory particles
   (d) Golgi bodies (of plant cells)

2. The endoskeleton of the cell is made up of
(a) Cell wall (b) Endoplasmic reticulum
(c) Cytoplasm (d) Mitochondria

3. Golgi body originated from
(a) Lysosome (b) Endoplasmic reticulum
(c) Mitochondria (d) Cell membrane

4. Which of the following statements is true for a secretory cell
(a) Golgi apparatus is absent
(b) Rough Endoplasmic Reticulum (RER) is easily observed in the cell
(c) Only Smooth Endoplasmic Reticulum (SER) is present
(d) Secretory granules are formed in the nucleus

5. One of the following serves as a temporary storage place for proteins and other compounds synthesized by endoplasmic reticulum
(a) Lysosomes (b) Sphaerosomes
(c) Microsomes (d) Dictyosomes

6. Zone of exclusion is associated with
(a) Golgi complex (b) Endoplasmic reticulum
(c) Mitochondria (d) Chloroplast

7. See the figure and identify it

(a) RER (b) GB
(c) SER (d) None

9. Lysosome and Ribosomes

1. "Lysosomes" were discovered by
(a) Haekel (b) De Duve
(c) De Vries (d) Purkinje

2. The cell organelle showing extensive polymorphism is
(a) Dictyosomes (b) Chloroplasts
(c) Lysosomes (d) Ribosomes

3. Which of the following is present both in prokaryotic and eukaryotic cells
(a) Mitochondria (b) Endoplasmic reticulum
(c) Ribosomes (d) Nucleus

4. Who discovered "ribosomes" in animal cells
(a) Watson (b) Talvim
(c) Cowdry (d) Palade

5. Lysosomes have acidic environment inside their vesicles due to
(a) Production of carboxylate ions inside it
(b) Production of phosphate ions inside it
(c) High *pH* compared to outside
(d) None of the above

6. Ribosomes are found in
(a) Cytoplasm (b) Nucleus
(c) Cell wall (d) Golgi body

7. Ribosomes are made up of
(a) DNA and protein (b) DNA alone
(c) RNA and protein (d) RNA and DNA

8. All are membrane-bound cell organelles except

Or

Which of the following cell organelles lacks a unit membrane
(a) Mitochondria (b) Lysosomes
(c) Sphaerosomes (d) Ribosomes

9. Ribosomes of bacteria, mitochondria, prokaryotes (*Nostoc*) and chloroplast are of
(a) 50 S type (b) 80 S type
(c) 70 S type (d) 30 S type

10. Select one which is not true for ribosome
(a) Made of two sub units
(b) Form polysome
(c) May attach of mRNA
(d) Have no role in protein synthesis

11. Which of the following is not true of a eukaryotic cell
(a) It has the 80S type of ribosome present in the mitochondria
(b) It has the 80S type of ribosome present in the cytoplasm
(c) Mitochondria contain circular DNA
(d) Membrane-bound organelles are present

12. Which of the following statements is incorrect with reference to lysosomes
(a) They have filled acid hydrolase and other enzymes
(b) They are monomorphic and uniform in structure and function
(c) They may be autophagic
(d) They can digest proteins, nucleic acids, lipids and polysaccharides

13. Secondary lysosomes are also called
(a) Autophagic vacuoles (b) Lipofuscin granules
(c) Residual body (d) Heterophagosomes

14. The "marker" enzyme of the lysosome is
(a) Lysozyme (muramidase) (b) Acid protease
(c) Acid phosphatase (d) Beta-galactosidase

10. Sphaerosomes, Peroxisomes, Glyoxysomes and Vacuoles

1. Peroxisomes are rich in
(a) DNA (b) RNA
(c) Catalytic enzymes (d) Oxidative enzymes

2. Tonoplast is a
(a) Unit membrane of golgi complex
(b) Unit membrane of vacuoles
(c) Unit membrane of microbodies
(d) Non-living cytoplasmic content

3. What is a tonoplast
(a) The outer membrane of mitochondria
(b) The inner membrane of the chloroplast
(c) Membrane boundary of the vacuole of plant cells
(d) The cell membrane of a plant cell

11. Centrosomes / Centriole Cilia, Flagella and Microtubules

1. Function of centriole is
   (a) Formation of spindle fibers
   (b) Formation of nucleolus
   (c) Initiation of cell division
   (d) Formation of the cell plate

2. A plant cell usually differs from an animal cell in the absence of

   Or

   Plant cells normally lack
   (a) Ribosomes (b) Centriole
   (c) Mitochondria (d) E.R.

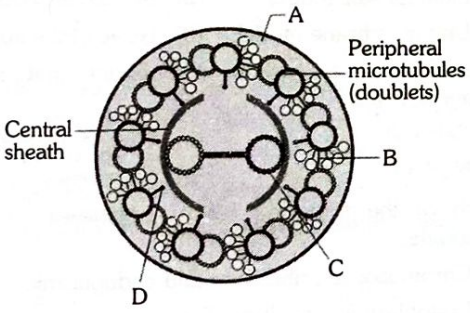
3. The main structure of centriole is
   (a) 9 + 3 fibrils (b) 9 + 2 fibrils
   (c) Nine triplets (d) 13 globular subunits

4. The principal protein of cilia and flagella is
   (a) Tubulin (b) Albumin
   (c) Globulin (d) Gliadin

5. Pattern of organisation of cilia and flagella is
   (a) 9 + 0 (b) 9 + 1
   (c) 9 + 2 (d) 9 + 3

6. The number of membranes that surround centrioles structure is
   (a) 3 (b) 0
   (c) 1 (d) 2

7. See the section of cilia/flagella showing the different parts



   In which of the following options all the four blanks A, B, C, and D are correctly identified
   (a) A – Plasma membrane, B – Interdoublet bridge, C – Hub, D – Arm
   (b) A – Plasma membrane, B – Interdoublet bridge, C – Hub, D – Radial spoke
   (c) A – Plasma membrane, B – Arm, C – Central microtubule, D – Radial spoke
   (d) A – Plasma membrane, B – Interdoublet bridge, C – Central microtubule, D – Radial spoke

12. Nucleus and Chromosomes

1. The term 'nucleolus' was coined by
   (a) R. Brown (b) H. Hooks
   (c) Bowman (d) Hanstein

2. Controlling centre of cell is
   (a) Nucleus (b) Nucleolus
   (c) Mitochondria (d) Ribosome

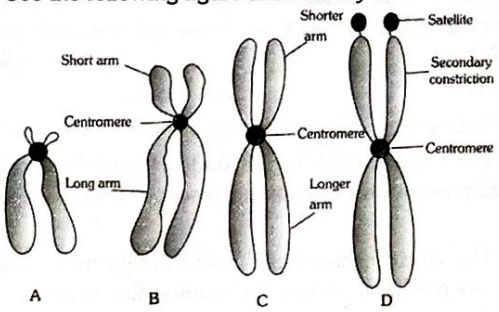
3. Karyology is the study of
   (a) Cell (b) Nucleus
   (c) Tissue (d) Genes

4. L-shaped chromosomes are called

   Or

   When the chromosome has a centromere nearer to middle the chromosome resulting into one shorter and one long arm, the chromosome is termed as
   (a) Sex chromosome (b) Acrocentric
   (c) Telocentric (d) Sub-metacentric

5. See the following figure and identify it



	A	B	C	D
(a)	Metacentric chr.	Submetacentric chr.	Acrocentric chr.	Telocentric chr.
(b)	Submetacentric chr.	Metacentric chr.	Telocentric chr.	Acrocentric chr.
(c)	Acrocentric chr.	Telocentric chr.	Metacentric chr.	Submetacentric chr.
(d)	Telocentric chr.	Acrocentric chr.	Submetacentric chr.	Metacentric chr.

6. The nucleus is separated from the surrounding cytoplasm by a nuclear membrane, which is
   (a) Single layered with pores
   (b) Single layered without pores
   (c) Double layered with pores
   (d) Double layered without pores

7. Nucleolus in eukaryotic cells is
   (a) Visible in metaphase
   (b) The site for synthesis of RNA polymerase
   (c) Bounded by a membrane
   (d) The site of packaging of rRNAs with ribosomal proteins

8. Which of the following features is common to prokaryotes and many eukaryotes
   (a) Chromosomes present
   (b) Cell wall present
   (c) Nuclear membrane present
   (d) Sub cellular organelles present

13. NEET

1. A magnification of up to 100 million times is possible in **[2000]**
   (a) Scanning electron microscope
   (b) Electron transmission microscope
   (c) Scanning probe microscope
   (d) Photon tunneling microscope

2. Ultrastructure of the cell can be best studied by **[1999]**
(a) Autoradiography
(b) X-ray diffraction method
(c) Phase contrast microscope
(d) None of these

3. Agarose extracted from seaweeds finds use in **[2011]**
(a) Gel electrophoresis (b) Spectrophotometry
(c) Tissue culture (d) PCR

4. A student wishes to study the cell structure under a light microscope having $10X$ the eyepiece and $45X$ objective. He should illuminate the object by which one of the following colors of light so as to get the best possible resolution **[2005]**
(a) Blue (b) Green
(c) Yellow (d) Red

5. A major breakthrough in the study of cells came with the development of an electron microscope. This is because **[2006]**
(a) The electron beam can pass through thick materials, whereas light microscopy requires thin sections
(b) The electron microscope is more powerful than the light microscope as it uses a beam of electrons which has a wavelength much longer than that of photons
(c) The resolution power of the electron microscope is much higher than that of the light microscope
(d) The resolving power of the electron microscope is 200-350 *nm* as compared to 0.1-0.2 *nm* for the light microscope

6. Smallest known cell is **[1988]**
(a) *Acetabularia*
(b) *Nostoc*
(c) *Chlamydomonas*
(d) Pleuropneumonia like organism

7. Cytosomes are found in **[1993]**
(a) Chloroplasts (b) Bacteria
(c) Mitochondria (d) All of these

8. Middle lamella is made up of **[2002, 09]**
(a) Cellulose
(b) Suberin
(c) Calcium and magnesium pectate
(d) Lignin

9. Which one of the following structures between two adjacent cells is an effective transport pathway **[2009; 2010]**
(a) Plasmalemma (b) Plasmodesmata
(c) Plastoquinones (d) Endoplasmic reticulum

10. Which of the following elements is responsible for maintaining turgor in cells **[2018]**
(a) Calcium (b) Potassium
(c) Sodium (d) Magnesium

11. The plasma membrane consists mainly of **[2002; 2010]**
(a) Proteins embedded in a carbohydrate bilayer
(b) Phospholipids embedded in a protein bilayer
(c) Proteins embedded in a phospholipid bilayer
(d) Proteins embedded in a polymer of glucose molecules

12. Select the correct statement from the following regarding cell membrane **[2012]**
(a) Na^+ and K^+ ions move across the cell membrane by passive transport
(b) Proteins make up 60 to 70% of the cell membrane
(c) Lipids are arranged in a bilayer with polar heads towards the inner part
(d) Fluid mosaic model of the cell membrane was proposed by Singer and Nicolson

13. Which one of the following is not a constituent of the cell membrane **[2007]**
(a) Cholesterol (b) Glycolipids
(c) Proline (d) Phospholipids

14. Bulk drinking of fluid by cells is termed as **[1993;]**

Or

The process of sucking of fluid from the cell surface is called
(a) Phagocytosis (b) Pinocytosis
(c) Cyclosis (d) Osmosis

15. According to the mosaic model, the plasma membrane is made up of **[1988]**
(a) Cellulose and hemicellulose
(b) Phospholipid and integrate protein
(c) Phospholipid, extrinsic and intrinsic protein
(d) Phospholipid and hemicellulose

16. Which is the latest model that is proposed to explain the structure of the plasma membrane **[2002]**
(a) Fluid mosaic model (b) Molecular model
(c) Unit membrane model (d) None of the above

17. In eubacteria, a cellular component that resembles eukaryotic cell is **[2011]**
(a) Cell wall (b) Plasma membrane
(c) Nucleus (d) Ribosomes

18. Which of the following set of organelles having bio-membrane. **[2015]**
(a) Chromosomes, ribosome and endoplasmic reticulum
(b) Endoplasmic reticulum, ribosomes, and nuclei
(c) Lysosomes, Golgi apparatus, and mitochondria
(d) Nuclei, ribosomes, and mitochondria

19. Keeping in view the fluid mosaic model for the structure of cell membrane, which one of the following statements is correct with respect to the movement of lipids and proteins from one lipid monolayer to the other (described as flip-flop movement) **[2008, 09]**
(a) While proteins can flip-flop, lipids can not
(b) Neither lipids nor proteins can flip-flop
(c) Both lipids and proteins can flip-flop
(d) While lipids can rarely flip-flop, proteins can not

20. Which one of the following does not differ in *E. coli* and *Chlamydomonas* **[2012]**
(a) Ribosomes
(b) Chromosomal Organization
(c) Cell wall
(d) Cell membrane

21. According to the widely accepted "Fluid mosaic model" cell membranes are semi-fluid, where lipids and integral proteins can diffuse randomly. In recent years, this model has been modified in several respects. In this regard, which of the following statements is incorrect **[2005]**

(a) Proteins in cell membranes can travel within the lipid bilayer

(b) Proteins can also undergo flip-flop movements in the lipid bilayer

(c) Proteins can remain confined within certain domains of the membrane

(d) Many proteins remain completely embedded within the lipid bilayer

22. The main arena of various types of activities of a cell is **[2010]**

Or

Proteins required for the functioning of the nucleus are formed in **[2012]**

(a) Nucleus (b) Plasma membrane

(c) Mitochondrian (d) Cytoplasm

23. Select the wrong statement **[2018]**

(a) Mitochondria are the powerhouse of the cell in all kingdoms except Monera

(b) Pseudopodia are locomotory and feeding structures in Sporozoans

(c) Mushrooms belong to Basidiomycetes

(d) Cell wall is present in members of Fungi and Plantae

24. Organelles which are regarded as 'Powerhouse' of the cell and in which the oxidative reactions of the respiratory process takes place are

Or

Which of the following cell organelles is responsible for extracting energy from Carbohydrates to form ATP **[2017]**

(a) Chloroplast (b) Ribosomes

(c) Endoplasmic reticulum (d) Mitochondria

25. Folding of the inner membrane of mitochondria is called **[2010]**

(a) Cristae (b) Grana

(c) Calcium oxalate crystals (d) Sacs

26. Which of the following statements regarding mitochondrial membrane is not correct **[2006]**

(a) The inner membrane is highly convoluted forming a series of infoldings

(b) The outer membrane resembles a sieve

(c) The outer membrane is permeable to all kinds of molecules

(d) The enzymes of the electron transfer chain are embedded in the outer membrane

27. Which of the following is the correct pair **[1993]**

(a) DNA synthesis — Ribosomes

(b) Protein synthesis — Smooth E.R.

(c) Aerobic respiration — Cristae

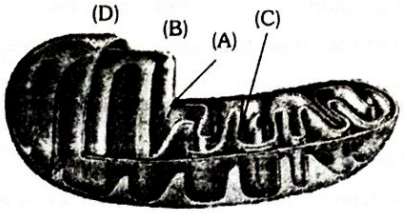
(d) Suicidal sacs — Dictyosomes

28. In mitochondria, protons accumulate in the **[2011]**

(a) Intermembrane space (b) Matrix

(c) Outer membrane (d) Inner membrane

29. The figure below shows the structure of a mitochondrion with its four parts labeled (A), (B), (C) and (D). Select the part correctly matched with its function **[2011]**



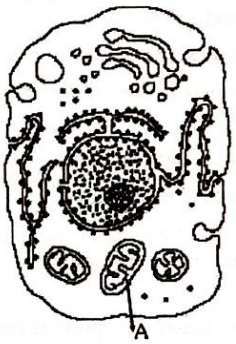
(a) Part (C): Cristae – possess single circular DNA molecule and ribosomes

(b) Part (A): Matrix – a major site for respiratory chain enzymes

(c) Part (D): Outer membrane – gives rise to inner membrane by splitting

(d) Part (B): Inner membrane – forms infoldings called cristae

30. Select the alternative giving correct identification and function of the organelle 'A' in the diagram **[2013]**



(a) Mitochondria – produce cellular energy in the form of ATP

(b) Golgi body – provides a packaging material

(c) Lysosomes – secrete hydrolytic enzymes

(d) Endoplasmic reticulum – a synthesis of lipids

31. Which of these statements is incorrect **[2018]**

(a) Oxidative phosphorylation takes place in outer mitochondrial membrane

(b) Glycolysis operates as long as it is supplied with NAD that can pick up hydrogen atoms

(c) Glycolysis occurs in cytosol

(d) Enzymes of TCA cycle are present in mitochondrial matrix

32. The bright colors of ripe fruits are due to **[2003]**

Or

Which of the following type of plastids does not contain stored food material **[2013]**

(a) Leucoplasts (b) Chloroplasts

(c) Amyloplasts (d) Chromoplasts

33. Which one of the following cellular parts are correctly described **[2012; 2015]**

(a) Thylakoids-flattened membranous sacs forming the grana of chloroplasts

(b) Centrioles-sites for active RNA synthesis

(c) Ribosomes-those on chloroplasts are larger (the 80s) while those in the cytoplasm are smaller (70s)

(d) Lysosomes-optimally active at a *pH* of about 8.5

34. In land plants, the guard cells differ from other epidermal cells in having **[2011]**

(a) Chloroplasts (b) Cytoskeleton

(c) Mitochondria (d) Endoplasmic reticulum

35. All plastids have essentially same structure because **[1994]**

(a) They have to perform the same function

(b) They are localized in aerial parts of the plant

(c) All plastids store starch, lipid, and proteins

(d) One type of plastids can be differentiated into another type of plastid depending on cell requirements

36. In chloroplasts, chlorophyll is present in the **[2004, 05]**

(a) Thylakoids (b) Stroma

(c) Outer membrane (d) Inner membrane

37. Select the wrong statement from the following **[2007]**

(a) Both chloroplasts and mitochondria contain an inner and an outer membrane

(b) Both chloroplasts and mitochondria have an internal compartment, the thylakoid space bounded by the thylakoid membrane

(c) Both chloroplasts and mitochondria contain DNA

(d) The chloroplasts are generally much larger than mitochondria

38. Mitochondria and Chloroplast are

(A) Semi-autonomous organelles

(B) Formed by the division of pre-existing organelles and they contain DNA but lack the protein synthesizing machinery

Which one of the following option is correct **[2016]**

(a) Both (A) and (B) are correct

(b) (B) is true but (A) is false

(c) (A) is true but (B) is false

(d) Both (A) and (B) are false

39. Which of the following is related to glycosylation of the protein **[2000]**

(a) ER (b) Peroxisome

(c) Lysosome (d) Mitochondria

40. An important site for the formation of glycoproteins and glycolipids is **[2011]**

(a) Lysosome (b) Vacuole

(c) Golgi apparatus (d) Plastid

41. Which of the following is the site of lipid synthesis **[2013; 2015]**

(a) Rough ER (b) Smooth ER

(c) Golgi bodies (d) Ribosome

42. The Golgi complex plays a major role **[1996; 2013]**

(a) In a post-translational modification of proteins and glycosylation of lipids

(b) In trapping the light and transforming it into chemical energy

(c) In digesting proteins and carbohydrates

(d) As energy transferring organelles

43. Identify the components labeled A, B, C and D in the diagram below from the list (i) to (viii) given along with **[2010; 2013]**

Components:

(i) Cristae of mitochondria

(ii) The inner membrane of mitochondria

(iii) Cytoplasm

(iv) Smooth endoplasmic reticulum

(v) Rough endoplasmic reticulum

(vi) Mitochondrial matrix

(vii) Cell vacuole

(viii) Nucleus

The correct components are

	A	B	C	D
(a)	(v)	(iv)	(viii)	(iii)
(b)	(i)	(iv)	(viii)	(vi)
(c)	(vi)	(v)	(iv)	(vii)
(d)	(v)	(i)	(iii)	(ii)

44. Which of the following events does not occur in rough endoplasmic reticulum **[2018]**

(a) Phospholipid synthesis

(b) Cleavage of signal peptide

(c) Protein glycosylation

(d) Protein folding

45. The Golgi complex participates in **[2018]**

(a) Activation of amino acid

(b) Respiration in bacteria

(c) Formation of secretory vesicles

(d) Fatty acid breakdown

46. The two sub-units of ribosome remain united at a critical ion level of **[2008]**

(a) Magnesium (b) Calcium

(c) Copper (d) Manganese

47. The organelles whose major function is storage of hydrolytic enzymes are **[1996]**

(a) Centrioles (b) Chromoplasts

(c) Lysosomes (d) Chloroplasts

48. Lysosomes are known as *suicidal bags* because of **[2000]**

Or

Which one of the following is stored in lysosome

(a) Catalytic enzymes (b) Hydrolytic enzymes

(c) Parasitic on nucleus (d) Proteolytic enzymes

49. Which one of the following structures is an organelle within an organelle **[2012]**

(a) Ribosome (b) Peroxisome
(c) ER (d) Mesosome

50. Ribosomes, similar to those of bacteria, are found in **[2001]**

(a) Plant nuclei
(b) Pancreatic mitochondria
(c) Liver endoplasmic reticulum
(d) Cardiac muscle cytoplasm

51. Which of the following cell organelles is having single-layered unit membrane **[2001; 2016]**

Or

In active leaf cells, the double membrane is absent in

(a) Centrosome (b) Lysosome
(c) Mesosome (d) Nucleus

52. The site of protein synthesis in plants is the **[1999]**

Or

Which of the following organelle is called as "protein factory of the cell"

(a) Chloroplast (b) Ribosomes
(c) Pyrenoids (d) Mitochondria

53. What is true about ribosomes **[2012]**

(a) The prokaryotic ribosomes are 80 *S*, where "S" stands for sedimentation coefficient
(b) These are composed of ribonucleic acid and proteins
(c) These are found only in eukaryotic cells
(d) These are self–splicing introns of some RNAs

54. Which of the following pairs is correct **[1993]**

(a) Svedberg unit — Biomembranes
(b) Polyribosomes — RNA
(c) Dictyosomes — Suicidal sacs
(d) Cisternae — Mitochondria

55. Polyribosomes are an aggregation of **[2008]**

(a) Ribosomes and rRNA
(b) Only rRNA
(c) Peroxisomes
(d) Several ribosomes held together by a string of mRNA

56. The functional unit in the synthesis of protein is **[1999]**

(a) Peroxisome (b) Dictyosome
(c) Lysosome (d) Polysome

57. Which of the following organ has a single membrane **[1999]**

(a) Nucleus (b) Cell wall
(c) Mitochondria (d) Sphaerosomes

58. Which one of the following is not considered as a part of the endomembrane system **[2011]**

(a) Vacuole (b) Lysosome
(c) Golgi complex (d) Peroxisome

59. The osmotic expansion of a cell kept in water is chiefly regulated by **[2014]**

(a) Plastids (b) Ribosomes
(c) Mitochondria (d) Vacuoles

60. In germinating seeds fatty acids are degraded *exclusively* in the **[2008]**

(a) Peroxisomes (b) Mitochondria
(c) Proplastids (d) Glyoxysomes

61. Vacuole in a plant cell **[2008]**

(a) Lacks membrane and contains air
(b) Lacks membrane and contains water and excretory substances
(c) Is membrane-bound and contains storage proteins and lipids
(d) Is membrane-bound and contains water and excretory substances

62. The function of centrosome is **[2000]**

(a) Inhibition of cell division
(b) Initiates cell division
(c) To increase protein synthesis
(d) None of these

63. Microtubule is involved in the **[1998]**

(a) Cell division (b) DNA recognition
(c) Muscle contraction (d) Membrane architecture

64. Prokaryotic flagella possess **[1995]**

(a) A helically arranged protein molecule
(b) Protein membrane-enclosed fiber
(c) Unit membrane-enclosed fiber
(d) Microtubular 9+2 membrane-enclosed structure

65. An elaborate network of filamentous proteinaceous structures present in the cytoplasm which helps in the maintenance of cell shape is called **[2010]**

(a) Thylakoid (b) Endoplasmic Reticulum
(c) Plasmalemma (d) Cytoskeleton

66. Microtubules are the constituents of **[2016]**

(a) Cilia, Flagella, and peroxisomes
(b) Spindle fibers, Centrioles, and Cilia
(c) Centrioles, Spindle fibers and Chromatin
(d) Centrosome, Nucleosome, and Centrioles

67. Which of the following statements regarding cilia is not correct **[2006]**

(a) Microtubules of cilia are composed of tubulin
(b) Cilia contain an outer ring of nine doublet microtubules surrounding two single microtubules
(c) The organized beating of cilia is controlled by fluxes of Ca^{2+} across the membrane
(d) Cilia are hair-like cellular appendages

68. The solid linear cytoskeletal elements having a diameter of 6 nm and made up of a single type of monomer are known as **[2014]**

(a) Intermediate filaments (b) Lamins
(c) Microtubules (d) Microfilaments

69. Match the following and select the **correct** answer

A.	Centriole	(i)	Infoldings in mitochondria
B.	Chlorophyll	(ii)	Thylakoids
C.	Cristae	(iii)	Nucleic acids
D.	Ribozymes	(iv)	Basal body cilia or flagella

[2014]

	A	B	C	D
(a)	(i)	(iii)	(ii)	(iv)
(b)	(iv)	(iii)	(i)	(ii)
(c)	(iv)	(ii)	(i)	(iii)
(d)	(i)	(ii)	(iv)	(iii)

70. Flagella of prokaryotic and eukaryotic cells differ in **[2004]**
(a) Microtubular organization and type of movement
(b) Microtubular organization and function
(c) Type of movement and placement in cell
(d) Location in cell and mode of unctioning

71. The function of the nucleolus is the synthesis of **[2012]**
(a) DNA (b) m-RNA
(c) r-RNA (d) t-RNA

72. Nucleoli are rich in **[1993]**
(a) DNA and RNA (b) DNA, RNA and proteins
(c) DNA (d) RNA

73. Spindle chromosomes have **[2000]**
(a) Centriole (b) Kinetochore
(c) Chrome centre (d) Chromomere

74. Nucleoproteins in a cell are synthesized in **[1989]**
(a) Outside the Nucleus (b) Nucleoplasm
(c) Nuclear membrane (d) Nucleolus

75. DNA is mainly found in **[1999]**
(a) Nucleus only (b) Nucleus and cytoplasm
(c) Cytoplasm only (d) All of these

76. Nucleoid is **[1989]**
(a) A single inactive nucleus having double-stranded DNA and proteins
(b) A group of chromosomes associated with proteins
(c) A nucleus without nuclear membrane and nucleolus or genetic material of prokaryotes
(d) A chromosome associated with proteins

77. Spindle fibers attach on to **[2016]**
(a) Telomere of the chromosome
(b) Kinetochore of the chromosome
(c) The centromere of the chromosome
(d) Kinetosome of the chromosome

78. Which of the following is true for nucleolus **[2018]**
(a) It is a site for active ribosomal RNA synthesis
(b) It takes part in spindle formation
(c) It is a membrane-bound structure
(d) Larger nucleoli are present in dividing cells

79. A protoplast is a cell **[2015]**
(a) Without nucleus
(b) Undergoing division
(c) Without cell wall
(d) Without plasma membrane

80. The type of cell junction which facilitates cell to cell communication is **[2015]**
(a) Tight junction (b) Adhering junction
(c) Gap junction (d) Desmosomes
(e) Brush borders

81. Protein synthesis in an animal cell takes place **[1997]**
(a) Only in the cytoplasm
(b) In the cytoplasm as well as in mitochondria
(c) In the nucleolus as well as in the cytoplasm
(d) Only on ribose attached to nucleon

82. Match the columns and identify the correct option

Column - I		Column - II	
(A)	Thylakoids	(i)	Disc-shaped sacs in Golgi apparatus
(B)	Cristae	(ii)	Condensed structure of DNA
(C)	Cisternae	(iii)	Flat membranous sacs in stroma
(D)	Chromatin	(iv)	Infoldings in mitochondria

[2015]

(a) (iii) (iv) (i) (ii)
(b) (iii) (i) (iv) (ii)
(c) (iii) (iv) (ii) (i)
(d) (iv) (iii) (i) (ii)

83. The nuclear envelope is a derivative of **[2015]**
(a) Membrane of Golgi complex
(b) Microtubules
(c) Rough endoplasmic reticulum
(d) Smooth endoplasmic reticulum

84. Which of the following cell organelle lacks DNA and bounding membrane **[2015; 2015]**
(a) Ribosome (b) Plastid
(c) Nucleolus (d) Plasmid

14. AIIMS

1. Who invented the "electron microscope"? **[2003]**
(a) Knoll and Ruska (b) Robert Brown
(c) Correns (d) Janssen and Janssen

2. The microscope usually used for seeing living cells or tissues is **[2012]**
(a) Compound microscope (b) Electron microscope
(c) Phase contrast microscope (d) Light microscope

3. Who proposed the "Cell theory" **[2011]**
(a) Schleiden (botanist) and Schwann (zoologist)
(b) Watson and Crick
(c) Mendel and Morgan
(d) Robert Hooke

5. Desmosomes are concerned with **[2010]**
(a) Cell division (b) Cellular excretion
(c) Cytolysis (d) Cell adherence

6. The cytoplasm of one cell is connected with other through **[2003]**
(a) Cytoplasmic strands (b) Plasmodesmata
(c) Torus (d) Pit membrane

7. In which part of mitochondria, ATP is generated **[1986]**
(a) Matrix (b) Cristae
(c) Outer membrane (d) F_1 particles (oxysomes)

8. What is common between chloroplasts, chromoplasts, and leucoplasts **[2008]**
(a) Presence of pigments
(b) Possession of thylakoids and grana
(c) Storage of starch, proteins, and lipids
(d) Ability to multiply by a fission–like a process

9. The term chromatophore was coined by **[1998]**
(a) Schmitz (b) Compare the
(c) W. Pfeffer (d) Singer and Nicolson

10. Many cells function properly and divide mitotically even though they do not have **[2005]**
(a) Plasma membrane (b) Cytoskeleton
(c) Mitochondria (d) Plastids

11. When the region of the endoplasmic reticulum is studied by ribosome on their outer surface of the cisternae, it is called **[2000]**
(a) Sarcoplasmic reticulum
(b) Smooth endoplasmic reticulum
(c) Granular endoplasmic reticulum
(d) None of the above

12. Mechanical support, enzyme circulation, protein synthesis and detoxification of drugs are a function of **[1999]**

Or

Which of the following is related to glycosylation of the protein
(a) *ER* (b) Ribosomes
(c) Dictyosomes (d) Chloroplast

13. The Golgi apparatus contains **[1993]**
(a) DNA
(b) RNA
(c) Phospholipids, proteins, enzymes and vitamin C
(d) Protein–lipid-protein

14. Which of the following four cell structures is correctly matched with the accompanying description **[2009]**
(a) Plasma membrane – Outer layer of cellulose or chitin, or absent
(b) Mitochondria – Bacteria like elements with the inner membrane forming sacs containing chlorophyll, found in plant cells and algae
(c) Chloroplasts – Bacteria like elements with inner membrane highly folded
(d) Golgi apparatus – Stacks of flattened vesicles

15. Three of the following statements regarding cell organelles are correct while one is wrong. Which one is wrong **[2005]**
(a) Lysosomes are double-membrane vesicles budded off from Golgi apparatus and contain digestive enzymes
(b) Endoplasmic reticulum consists of a network of membranous tubules and helps in transport, synthesis, and secretion
(c) Leucoplast are bound by two membranes, lack pigment but contain their own DNA and protein-synthesizing machinery
(d) Sphaerosomes are single membrane-bound and are associated with synthesis and storage of lipids

16. In which one of the following would you expect to find glyoxysomes **[2005]**
(a) Endosperm of wheat (b) Endosperm of castor
(c) Palisade cells in leaf (d) Root hairs

17. The fluid part of the cell called *cell sap* is the **[1993]**
(a) Non-living contents of a cell
(b) Living contents of a cell
(c) Non-living contents of the vacuole of the cell
(d) Living contents of the vacuole of the cell

18. The filaments associated with cilia and flagella are constituted by **[1994]**
(a) Microtubules (b) Microfilaments
(c) Microfibrils (d) Microvilli

19. Microtubules are absent in **[2010]**
(a) Mitochondria (b) Flagella
(c) Spindle fibres (d) Centriole

20. In nucleoplasm, a conspicuous body of spherical shape attached to a particular chromosome on a definite position is called **[1998]**
(a) Plasmid (b) Karyolymph
(c) Nucleolus (d) Nuclear reticulum

21. The telomeres of eukaryotic chromosomes consist of short sequences of **[2007]**
(a) Adenine rich repeats (b) Guanine rich repeats
(c) Thymine rich repeats (d) Cytosine rich repeats

15. Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below:
(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Mitochondria and chloroplasts are semiautonomous organelles.
Reason : They are formed by the division of pre-existing organelles as well as contain DNA but lack protein synthesizing machinery

2. Assertion : Lysosomes help in photorespiration.
Reason : Lysosome has basic enzyme.

3. Assertion : The number of cells in a multicellular organism is inversely proportional to the size of the body.
Reason : All the cells in the biological world are of the same size.

4. Assertion : Schleiden and Schwann were the first to observe the cells and to put forward cell theory.
Reason : The cells are always living unit.

6. Assertion : Mitochondria is known as power house of cell.
Reason : ATP production takes place here.

7. Assertion : It is important that the organisms should have a cell.
Reason : A cell keeps its chemical composition steady within its boundary.

8. Assertion : Cell wall is not found in the animal cell.
Reason : Animal cells are covered by the cell membrane.

9. Assertion : Cell membrane is semipermeable.
Reason : The constituent molecules can freely move in the membrane.