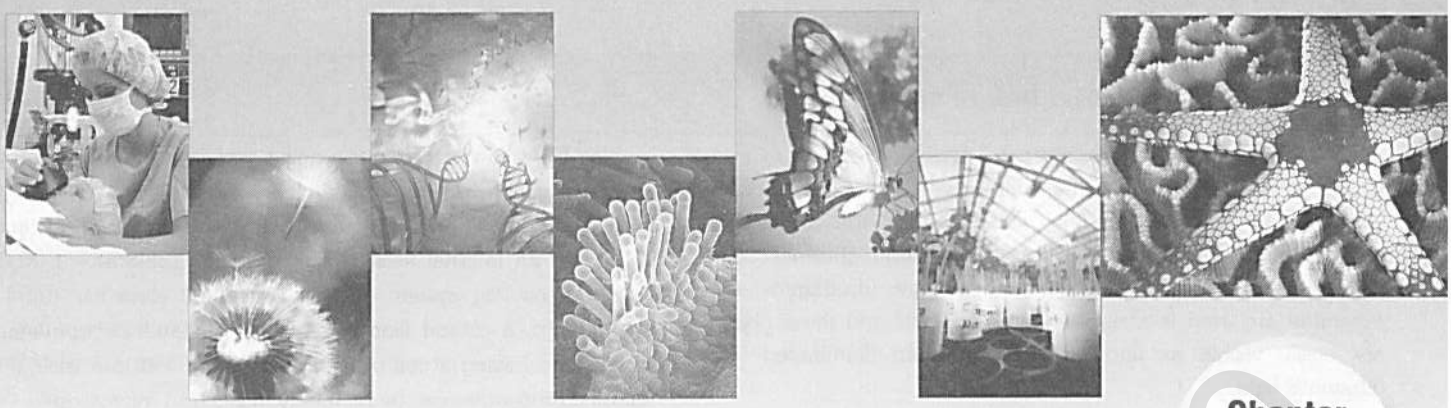


Chapter

3.1

Cell : The Unit of Life

Microscopy

Microscopy (*Gk. Micros* = small ; *skopein* = to see) is practice of using microscopes for the study of finer details of small objects including cells and tissues. 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 $\sin 70^\circ = 0.94$.

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.

Types of microscopes

(1) **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. It was the first tool ever used to observe biological objects. Its magnification power was 14 – 42 times only, so it is considered as simple microscope.

(2) **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. However, it was not used for laboratory study. 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 and the magnification is independent of intensity of light, size of microscope and numerical aperture. The light microscope is also called *bright field* microscope because it forms the image when light is transmitted through the object.

(3) **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.

(4) **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.

(5) **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.

(6) **Phase contrast microscope**

(i) Discovered by Dutch man *Fredericke Zernicke* (1935).

(ii) Source of illumination is visible light.

(iii) It is used to study living cells and tissues without staining and effect of chemical and physical agents on the living cells.

(iv) It is also used to study spindle formation, pinocytosis, karyokinesis, cytokinesis etc.

(v) The demerit of this microscope is subcellular organelles smaller than 0.2μ, (like ribosomes, lysosomes, ER) cannot be visualised.

(7) **Interference microscope (Morten et.al.)**

(i) It's principle is similar to that of the phase contrast microscope and gives / studies quantitative data.

(ii) Nomarski interference contrast microscope is useful to study mitosis /cell components in living state.

(iii) 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.

(8) **Dark field microscope**

(i) *Zsigmondy* (1905) invented this microscope.

(ii) It is based on the fact that light is scattered at boundaries between regions having different refractive index.

(iii) The object smaller than those seen with ordinary light microscope can be detected but can not be resolved.

(9) **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 cathod 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. The magnetic field produced is concentrated by soft iron casing. When the filament is heated to incandescence, it emits electron. The electrons then move to positively charged anode. The entire microscope column operates under conditions of high vacuum. It is due to this fact that we can not observe living objects through an electron microscope (EM). For viewing objects under EM, ultrathin sections (20-100 *nm* thick) are prepared through an ultramicrotone. 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 can not 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 :

(i) **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.

(ii) **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*.

(10) **Advanced high power microscope**

(i) **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.

(ii) **Scanning tunnelling 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.

(iii) **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.

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) = $10^{-9}\,m$, $10^{-7}\,cm$, $10^{-6}\,mm$, $10^{-3}\,\mu m = 10\text{Å}$

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*.

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.

Table : 3.1-1 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

Cell fractionation

In isotonic medium cell components are separated, in two steps process.

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

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.

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.

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.

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.

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.

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.

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. Their fate is recorded by mass spectroscopy and density gradient centrifugation. Meselson and Stahl (1958) studied DNA replication and Ruben *et al* (1941) evolution of oxygen (photolysis of water) in photosynthesis by using heavy isotopes.

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.

Cell as a 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.

Cell theory : H.J. Dutrochet (1824) a French worker gave the idea of 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.

The cell as a self contained unit : Autonomy of a cell is believed due to presence of DNA and its expressibility, otherwise, cell components have different shape and function. It has two positions.

(1) **Autonomy in unicellular organisms :** Unicellular organisms leads to a totally independent life due to different shape, size and role of different organelles shows division of labour. All these display homeostasis. Unicellular organisms are more active due to large surface volume ratio.

(2) **Autonomy in multicellular organisms :** In multicellular organisms life activities are displayed by each of the cells independently. Multicellular organisms have one thing advantage over unicellular organisms is division of labour.

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.

Table : 3.1-2 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.
Lysosomes present in less number.	Lysosomes present in more number.

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.

Table : 3.1-3

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.

Cell wall

Discovery : It was first discovered by *Robert Hooke* in 1665 in Cork. Cell wall is the outer most, rigid, protective, non living and supportive layer found in all the plant cells, bacteria, cyanobacteria and some protists. It is not found in animal cells.

Chemical composition : Mainly cell wall consists of two parts, matrix and cellulosic fibres (microfibrils). Matrix consists of hemicellulose, pectin, glycoproteins, lipids and water. In most of the plants cell wall is made up of cellulose $(C_6H_{10}O_5)_n$, a polymer made-up of unbranched chain of glucose molecule linked by $\beta 1-4$ glycosidic bond. About 100 molecules of cellulose form a micelle, about 20 micelle form a microfibril and approx. 250 microfibril form a fibril.

The cell wall of bacteria and the inner layer of blue green algae is made-up mucopeptide. It is a polymer of two amino sugars namely N-acetyl glucosamine (NAG) and N-acetyl muramic acid (NAM) held alternately in β –1,4- linkage. In higher fungi, the cell wall is made up of chitin, polymer of glucosamine.

Structure : Cell wall consists of middle lamella, primary wall, secondary wall, tertiary wall.

(1) **Middle lamella :** Middle lamella is the outermost region which functions as a common cementing layer between two cells. It is absent on the outer free surface. It ruptures to create intercellular spaces. Middle lamella is formed of calcium and magnecium pectate. Calcium pectate is main component of middle lamella. Fruit softening is due to gelatinisation of pectic compounds of middle lamella. Pectin is used as commercial jellying agent, which is present outside the primary wall.

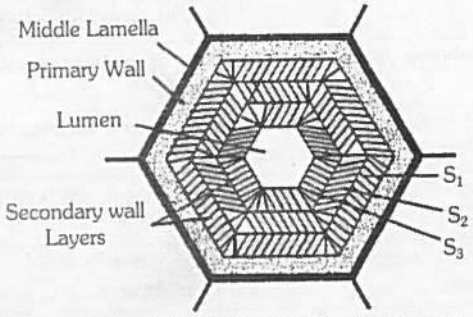


Fig : 3.1-1 T. S. of A Plant cell wall

(2) **Primary wall :** A young plant cell forms a single layer of wall material. This layer is known as the primary cell wall. The primary wall is thin, elastic and capable of expansion in a growing cell. It grows by intussusception. Meristematic and parenchymatous cells have primary cell wall only. The cells of leaves and fruits too have only primary wall. It has more hemicellulose and less cellulose.

(3) **Secondary wall :** In mature cell, more layers of wall material are added internal to the primary wall. These are called the secondary cell wall. Growth by addition of new wall material on the primary wall is called accretion. It has more cellulose and less hemicellulose. The secondary wall is thick and rigid. It usually consists of three layers, which are often named S_1, S_2 and S_3. It is found in collenchyma and sclerenchyma cells, xylem vesseles.

(4) **Tertiary wall :** Sometimes tertiary wall is laid down on secondary wall, *e.g.*, tracheids of gymnosperms. It is composed of cellulose and xylan.

Origin : A cell wall is organise at telophase stage of cell division. The plane and place of cell wall is determined by the microtubules. Fragments of ER and vesicles of golgi body aligned at the equator, called as phragmoplast, later which forms the cell plate. The synthesis of cellulose takes place by the help of enzyme *cellulase* synthetase present in the plasma membrane. The cell plate forms the cell wall. Beside these, different materials are deposited as :

(i) **Lignin :** It is special type of polysaccharide which deposits mainly in xylem cells and makes them hard and lignified. Due to its deposition xylem tracheids take up different forms, *e.g.*, annular thickening, spiral thickening, scalariform thickening.

(ii) **Cutin :** It is a wax-like fatty substance. It is deposited on the epidermal cells in the form of cuticle which reduces loss of water. Cuticle is very thick in xerophytes, thin in mesophytes and absent in hydrophytes.

(iii) **Suberin :** It is a complicated mixture of fatty acids deposited on cork cells. Suberin is impermeable to water.

(iv) **Mucilage :** Some cells are slippery to touch due to secretion of mucilage, *e.g.*, blue-green algae. The cells can withstand extremes of temperature, *i.e.*, very low or very high.

(v) **Silica :** In some cases sand or silica particles are deposited which give a rough touch, *e.g.*, *Equisetum* and *Saccharum munja*.

In family Moraceae, Urticaceae, Cucurbitaceae and Acanthaceae, *Ca* oxalate and *Ca* carbonate crystals are deposited.

Growth of cell wall

(1) **By intussuception :** As the cell wall stretches in one or more directions, new cell wall material secreted by protoplasm gets embedded within the original wall.

(2) **By apposition :** In this method new cell wall material secreted by protoplasm is deposited by definite thin plates one after the other.

Thickenings of cell wall : In many secondary walls specially those of xylem the cell wall becomes hard and thick due to the deposition of lignin. With the increasing amount of lignin, deposition protoplasm is lost. First the lignin is deposited in middle lamella and primary wall and later on in secondary wall.

Pits : Secondary walls may have irregular thickenings at some places and these places are called pits. Pits are of five types :

(1) **Simple pit :** In which pit chamber is uniform in diameter.

(2) **Bordered pit :** In which pit chamber is flask shaped in tracheids of gymnosperm and vessels of angiosperms.

(3) **Blind pit :** A pit without any corresponding pit on the adjacent wall is called blind pit.

(4) **Half bordered pit :** A pit with half border and the rest half with a simple pit.

(5) **Aspirated pit :** It is a non-functional pit in which the pit aperture is blocked permanently by torus.

Plasmodesmata : *Tangle* (1879) first of all discovered them and were studied elaborately by *Strasburger* (1901). A number of plasmodesmata or cytoplasmic strands are present in pit through which the cytoplasm of one cell is in contact with another. Endoplasmic reticulum plays a role in origin of plasmodesmata.

Functions of cell wall

(1) It maintains shape of the plant cells and protect the cells from mechanical injury.

(2) It wards off the attacks of pathogens (viruses, bacteria, fungi, protozoans).

(3) It provides mechanical support against gravity. It is due to the rigid cell wall that the aerial parts of the plants are able to keep erect and expose their leaves to sunlight.

(4) The cell wall prevents undue expansion of the cell when water enters by osmosis to compensate for the lack of contractile vacuole. This prevents bursting of cells.

(5) Though permeable, the cell wall plays some regulatory role on the passage of materials into and out of the cell.

(6) Pores in the cell walls permit plasmodesmata to link up all the protoplasts into a system called symplast (symplasm).

(7) Cell wall and intercellular spaces constitute a nonliving component of plant body known as apoplasm.

Plasma membrane

Every living cell is externally covered by a thin transparent electron microscopic, elastic regenerative and selective permeable membrane called plasma membrane. It is quasifluid in nature. Membranes also occur inside the cells. They are collectively called biomembranes. The term cell membrane was given by C. Nageli and C. Cramer (1855) for outer membrane covering of the portoplast. It was replaced by the term plasmalemma by Plower (1931).

Chemical composition : Proteins lipoprotein (Lipid +Protein) are the major component forming 60% of the plasma membrane. Proteins provide mechanical strength and responsible for transportation of different substances. Proteins also act as enzyme. Lipids account may 28%-79% depending upon the type of cell and organism involved (in humans, myelin 79%). The lipids of plasma membrane are of three types namely **phospholipids, glycolipids** and **sterols**. The sterol found in the membrane may be cholesterol (Animals), phytosterol (Plants) or ergosterol (Microorganisms).

Carbohydrates form 2%–10%. Oligosaccharides are the main carbohydrates present in plasma membrane. The carbohydrates of plasma membrane are covalently linked to both lipid and protein components.

Ultrastructure : Under electron microscope the plasma membrane appears three layered, *i.e.*, trilaminar or tripartite. One optically light layer is of lipid and on both sides two optically dense protein layers are present.

Molecular structure and different models : Several models have been proposed to explain the structure and function of the plasma membrane.

(1) **Overton's model :** It suggests that the plasma membrane is composed of a thin lipid single layer.

(2) **Sandwitch model :** It was proposed by Davson and Danielli (1935). According to this model the light biomolecular lipid layer is sandwitched between two dense protein layers (globular α type protein). This model was also said to be unit membrane hypothesis.

(3) **Robertson's unit membrane model :** It states that all cytoplasmic membranes have a similar structure of three layers with and electron transparent phospholipid bilayer being sandwitched between two electron dense layer of proteins (extended or β type protein).

Its thickness is about 75 Å with a central lipid layer of 35 Å thick and two peripheral protein layers of 20 Å thick.

(4) **Fluid mosaic model :** The most important and widely accepted latest model for plasma membrane was given by *Singer and Nicolson in* 1972. According to them it is "protein iceberg in a sea of lipids."

According to this model, the cell membrane consists of a highly viscous fluid matrix of two layers of phospholipid molecules. Protein molecules occur as separate particles asymmetrical arranged in a mosaic pattern.

Some of these are loosely bound at the polar surfaces of lipid layers, called peripheral or extrinsic proteins. Others penetrate deeply into the lipid layer called integral or intrinsic proteins. Some of the integral proteins penetrate through the phospholipid layers and project on both the surface. These are called trans membrane or tunnel proteins (glycophorins). Singly or in groups, they function as channels for passage of water ions and other solutes.

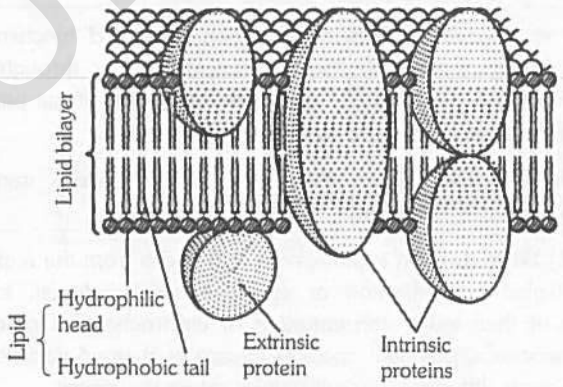


Fig : 3.1-2 Fluid-mosaic model of the plasma membrane structure

The carbohydrates occur only at the outer surface of the membrane. Their molecules are covalently linked to the polar heads of some lipid molecules (forming glycolipids) and most of the proteins exposed at outer surface (forming glycoproteins). Through glycoproteins, bacteria recognise each other. *e.g.*, female bacteria are recognised by male bacteria.

Modification of plasma membrane

(1) **Microvilli :** They are finger like evaginations of 0.1 μm diameter, engaged in absorption. *e.g.*, intestinal cells, hepatic cells, mesothelial cells. The surface having microvilli is called striated border or brush border.

(2) **Lomasomes :** They are plasmalemma foldings found in fungal cells. These were reported by Moore and Maclean.

(3) **Mesosomes :** It serves as site for cellular respiration in prokaryotes.

(4) **Tight junctions or (Zonulae occludents) :** Plasma membrane of two adjacent cells are fused at a series of points with a network of ridges or sealing strands. *e.g.*, capillaries, brain cells collecting tubules etc.

(5) **Desmosomes :** Concerned with cell adherence.

(6) **Transosomes :** It is found in follicular cells of ovary of birds and have triple unit membrane. First reported by Press (1964).

Functions

(1) It not only provides mechanical strength but also acts as a protective layer.

(2) Plasma membrane is responsible for the transportation of materials, molecules, ions etc.

(3) It helps in osmoregulation.

(4) Diffusion of gases (O_2 and CO_2) take place through plasma membrane by simple and facilitated diffusion.

(5) Water as well as some solute molecules and ion pass through membrane pores; pores are always bordered by channel proteins.

Membrane transport

It is passage of metabolites, by-products and biochemicals across biomembrane. Membrane transport occurs through four methods–passive, facilitated, active and bulk. Size of the particles passing through plasmalemma is generally 1 – 15 Å.

Passive transport : No energy spent. Passive transport occurs through diffusion and osmosis.

(1) **Diffusion :** It is movement of particles from the region of their higher concentration or electrochemical potential to the region of their lower concentration or electrochemical potential. Electrochemical potential operates in case of charged particles like ions. Simple diffusion does not require carrier molecules.

(2) **Osmosis :** It is diffusion of water across a semipermeable membrane that occurs under the influence of an osmotically active solution.

Mechanism of passive transport : Passive transport can continue to occur if the absorbed solute is immobilised. Cations have a tendency to passively pass from electropositive to electronegative side. While anions can pass from electronegative to electropositive side. There are two modes of passive transport.

(1) **Lipid matrix permeability :** Lipid soluble substances pass through the cell membrane according to their solubility and concentration gradient, *e.g.*, triethyl citrate, ethyl alcohol, methane.

(2) **Hydrophilic membrane channels :** They are narrow channels formed in the membrane by tunnel proteins. The channels make the membrane semipermeable. Water passes inwardly or outwardly from a cell through these channels according to osmotic gradients. CO_2 and O_2 also diffuse through these channels as per their concentration gradients.

Facilitated transport or Facilitated diffusion : It is passage of substances along the concentration gradient without expenditure of energy that occurs with the help of special permeating substances called permeases. Permeases form pathways for movement of certain substances without involving any expenditure of energy. Facilitated transport occurs in case of some sugars, amino acids and nucleotides.

Active transport : It occurs with the help of energy, usually against concentration gradient. For this, cell membranes possess carriers and gated channels. At times certain substances are transported alongwith the ones requiring active transport. The latter phenomenon called cotransport.

(1) **Carrier particles or Proteins :** They are integral protein particles which have affinity for specific solutes. A solute particles combines with a carrier to form carrier solute complex. The latter undergoes conformational change in such a way as to transport the solute to the inner side where it is released into cytoplasm.

(2) **Gated channels :** The channels are opened by either change in electrical potential or specific substances, *e.g.*, Calcium channels.

Active transport systems are also called pumps. The pumps operate with the help of ATP. $K^+ - H^+$ exchange pump occurs in guard cells. $Na^+ - K^+$ exchange pump operates across many animal membranes.

Active transport of one substance is often accompanied by permeation of other substances. The phenomenon is called secondary active transport. It is of two main types, cotransport (*e.g.*, glucose and some amino acids alongwith inward pushing of excess Na^+) and counter-transport (Ca^{2+} and H^+ movement outwardly as excess Na^+ passes inwardly).

Bulk transport : It is transport of large quantities of micromolecules, macromolecules and food particles through the membrane. It is accompanied by formation of transport or carrier vesicles. The latter are endocytotic and perform bulk transport inwardly. The phenomenon is called **endocytosis**. Endocytosis is of two types, pinocytosis and phagocytosis. Exocytic vesicles perform bulk transport outwardly. It is called exocytosis. Exocytosis performs secretion, excretion and ephagy.

(1) **Pinocytosis :** (Lewis, 1931). It is bulk intake of fluid, ions and molecules through development of small endocytotic vesicles of 100 – 200 *nm* in diameter. ATP, Ca^{2+}, fibrillar protein clathrin and contractile protein actin are required. Fluid-phase pinocytosis is also called cell drinking. After coming in contact with specific substance, the area of plasma membrane having adsorptive sites, invaginates and forms vesicle. The vesicle separates. It is called **pinosome**. Pinosome may burst in cytosol, come in contact with tonoplast and pass its contents into vacuole, form digestive vacuole with lysosome or deliver its contents to Golgi apparatus when it is called **receptosome**.

(2) **Phagocytosis :** (Metchnikoff, 1883). It is cell eating or ingestion of large particles by living cells, *e.g.*, white blood corpuscles (neutrophils, monocytes), Kupffer's cells of liver, reticular cells of spleen, histiocytes of connective tissues, macrophages, Amoeba and some other protists, feeding cells of sponges and coelenterates. Plasma membrane has receptors. As soon as the food particle comes in contact with the receptor site, the edges of the latter evaginate, form a vesicle which pinches off as phagosome.

One or more lysosomes fuse with a phagosome, form digestive vacuole or food vacuole. Digestion occurs inside the vacuole. The digested substances diffuse out, while the residual vacuole passes out, comes in contact with plasma membrane for throwing out its contents through **exocytosis** or ephagy.

Protoplasm (Proto = first, plasm = fluid)

Protoplasm is a complex, granular, elastic, viscous and colourless substance. It is selectively or differentially permeable. It is considered as "Polyphasic colloidal system".

Discoveries

(1) J. Huxley defined it as "physical basis of life".

(2) *Dujardin* (1835) discovered it and called them "sarcode".

(3) Purkinje (1837) renamed it as "Protoplasm".

(4) *Hugo Von Mohl* (1844) gave the significance of it.

(5) *Max Schultz* (1861) gave the protoplasmic theory for plants.

(6) *Fischer* (1894) and *Hardy* (1899) showed its colloidal nature.

(7) *Altman* (1893) suggested protoplasm as granular.

Table : 3.1-4 Chemically composition

Water	75 – 85%	Carbon	20%
Proteins	10 – 25%	Oxygen	62%
Lipids	2 – 3%	Hydrogen	10%
Inorganic materials	1%	Nitrogen	3%
Trace elements 5% (*Ca, P, Cl, S, K, Na, Mg, I, Fe* etc.)			

Maximum water content in protoplasm is found in hydrophytes, *i.e.*, 95% where as minimum in seeds, spores (dormant organs) *i.e.*, 10 – 15%. In animals water is less (about 65%) and proteins are more (about 15%).

Theories regarding nature of protoplasm

Following theories have been put forth regarding the nature of protoplasm.

(1) **Reticular theory :** Protoplasm possesses a delicate reticular structure. (by Heitzman)

(2) **Granular theory :** Protoplasm consists of numerous minute granules (by Altman).

(3) **Fibrillar theory :** Protoplasm is formed of fibres and these are proteinous nature. (by Flemming)

(4) **Alveolar theory :** It consists of droplets of alveoli or minute bubbles resembling foams of emulsion (by Butschil).

(5) **Colloidal theory :** Protoplasm is a polyphasic colloidal system (by Fisher & Hardy)

(6) **Sol ⇔ gel theory :** Protoplasm is a colloidal solution consists of dispersion and dispersed phase. It exist in two state *i.e.*, **sol** state (more H_2O) and **gel** state (less H_2O). This theory was proposed by Hyman.

(7) **Crystallo Colloidal theory :** Protoplasm is crystal, polyphasic, colloidal solution made of various inorganic substances like protein, carbohydrates and fats. This theory was proposed by Kolliker. It is most advanced and accepted theory of protoplasm.

Properties of protoplasm

(1) **Cyclosis movement :** These are shown by protoplasm. These are of two types.

Rotation : In one direction, either clockwise or anticlockwise *e.g., Hydrilla, Vallisneria*. Found only in eukaryotes.

Circulation : Multidirectional movements around vacuole *e.g., Tradescantia*.

(2) It shows stimulation or irritability, Sol–gel transformation and Brownian movements.

(3) It is highly viscous and coagulates at 60° *C* or above or if treated with concentrated acids or bases.

(4) It's *pH* is on acidic side, but different vital activities occur at neutral *pH* which is considered as 7, injury decreases the pH of the cell (*i.e.*, 5.2 – 5.5) and if it remains for a long time, the cell dies.

Protoplast : A term coined by Hanstein (1880) include all the living constituents of the protoplasm viz. nucleus, cytoplasm and plasmalemma. It is a simply organized mass of protoplasm bounded by cell membrane with no cell wall.

Cytoplasm

The substance occuring around the nucleus and inside the plasma membrane containing various organelles and inclusions is called cytoplasm.

(1) The cytoplasm is a semisolid, jelly – like material. It consists of an aqueous, structureless ground substance called cytoplasmic matrix or hyaloplasm or cytosol.

(2) It forms about half of the cell's volume and about 90% of it is water.

(3) It contains ions, biomolecules, such as sugar, amino acid, nucleotide, tRNA, enzyme, vitamins, etc.

(4) The cytosol also contains storage products such as glycogen/starch, fats and proteins in colloidal state.

(5) It also forms crystallo – colloidal system.

(6) Cytomatrix is differentiated into ectoplasm or plasmagel (outer) and endoplasm or plasmasol (inner).

(7) Cytomatrix is three dimensional structure appear like a network of fine threads and these threads are called microfilaments (now called actin filaments or microtrabecular lattice) and it is believed to be a part of cytoskeleton. It also contains microtubules and intermediate cytoplasmic filaments.

(8) Hyaloplasm contains metabolically inactive products or cell inclusions called deutoplast or metaplasts.

(9) Cytoplasmic organelles are plastid, lysosome, sphaerosome, peroxisome, glyoxysomes, mitochondria, ribosome, centrosome, flagellum or cilia etc.

(10) The movement of cytoplasm is termed as cyclosis (absent in plant cells).

Mitochondria

Mitochondria (Gk. *Mito* = thread ; *chondrion* = granule) are semi autonomous having hollow sac like structures present in all eukaryotes except mature RBCs of mammals and sieve tubes of phloem. Mesosomes of prokaryotes (bacteria) is analogous to mitochondrion in eukaryotes.

Mitochondria are also called chondriosome, chondrioplast, plasmosomes, plastosomes and plastochondrione.

Discoveries

(1) These were first observed in striated muscles (Voluntary) of insects as granules by Kolliker (1850), he called them "sarcosomes".

(2) *Flemming* (1882) called them "fila" for thread like structure.

(3) *Altman* (1890) called them "bioplast".

(4) *C. Benda* (1897) gave the term mitochondria.

(5) *F. Meves* (1904) observed mitochondria in plant (Nymphaea).

(6) *Michaelis* (1898) demonstrated that mitochondria play a significant role in respiration.

(7) *Bensley* and *Hoerr* (1934) isolated mitochondria from liver cells.

(8) *Seekevitz* called them "Power house of the cell".

(9) *Nass* and *Afzelius* (1965) observed first DNA in mitochondria.

Number of mitochondria : Presence of mitochondria depends upon the metabolic activity of the cell. Higher is the metabolic activity, higher is the number *e.g.*, in germinating seeds.

(1) Minimum number of mitochondria is one in Microasterias, *Trypanosoma*, *Chlorella*, *Chlamydomonas* (green alga) and *Micromonas*. Maximum numbers are found (upto 500000) in flight muscle cell, (upto 50000) in giant *Amoeba* called *Chaos – Chaos*. These are 25 in human sperm, 300 – 400 in kidney cells and 1000 – 1600 in liver cells.

(2) Mitochondria of a cell are collectively called chondriome.

Size of mitochondria : Average size is 0.5–1.00 μm and length upto 1 – 10 μm. Smallest sized mitochondria in yeast cells ($1 \mu m^3$) and largest sized are found in oocytes of *Rana pipiens* and are 20 – 40 μm.

Ultrastructure : Mitochondria is bounded by two unit membranes separated by perimitochondrial space (6 – 10*nm* wide). The outer membrane is specially permeable because of presence of integral proteins called porins. The inner membrane is selective permeable. The inner membrane is folded or convoluted to form mitochondrial crests. In animals these are called cristae and in plants these folding are called tubuli or microvili.

The matrix facing face is called 'M' face and face towards perimitochondrial space is called 'C' face. The 'M' face have some small stalked particles called oxysomes or F_1 particle or elementary particle or Rackers particle or Fernandez – *Moran Particles* (10^4–10^5 per mitochondria). Each particle is made up of base, stalk and head and is about 10*nm* in length.

Oxysomes have ATPase enzyme molecule (Packer, 1967) and therefore, responsible for ATP synthesis. The reaction of ATP formation is endergonic. These elementary particles are also called $F_0 - F_1$ particles. The F_1 particle is made up of five types of subunits namely $\alpha, \beta, \gamma, \delta$ and ε. of these α is heaviest and ε is lightest. F_0 particles synthesize all the enzymes required to operate Kreb's cycle.

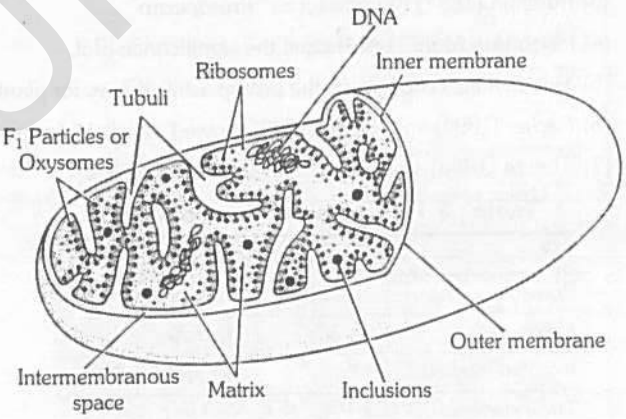


Fig : 3.1-3 Mitochondria of plant cell

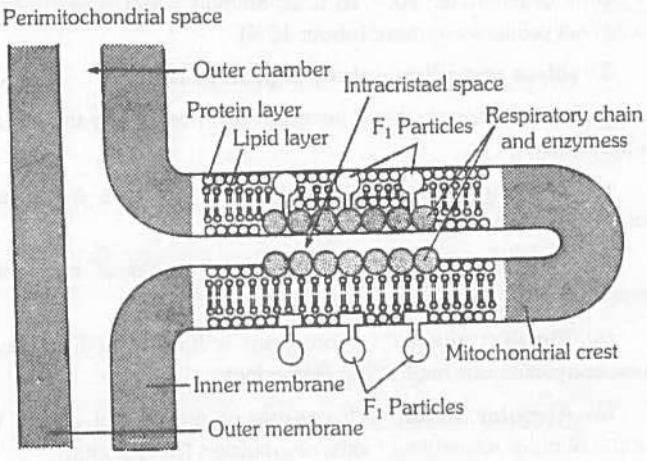


Fig : 3.1-4 Structure of inner membrane of mitochondria

Semi-autonomous nature of mitochondrion : Mitochondria contain all requirements of protein synthesis :

(1) 70 *S* ribosomes.

(2) DNA molecules (rich in G-C ratio) to form *m*RNA and also replicate.

(3) ATP molecules to provide energy.

The mitochondria can form some of the required proteins but for most of proteins, these are dependent upon nuclear DNA and cytoplasmic ribosomes, so the mitochondria are called semi-autonomous organelles.

According to endosymbiotic origin of mitochondria by Kirns Altman, mitochondria were intially a free living, aerobic bacteria which during to the process of evolution entered an anaerobic cell and become established as mitochondria. This theory is supported by many similarities which exist between bacteria and mitochondria.

Chemical composition : *Cohn* gave the chemical composition of mitochondrion :

Proteins = 65 – 70% ; Lipids = 25 – 30% (90% phospholipids and 10% cholesterol, Vit. E., etc.) ; RNA = 5 – 7%. Some amount of DNA 2 – 5%.

The mitochondrial matrix has many catabolic enzymes like cytochrome oxidase and reductases, fatty acid oxidase, transaminase, etc.

Enzymes of Mitochondria

(1) **Outer membrane :** Monoamine oxidase, glycerophosphatase, acyltransferase, phospholipase A.

(2) **Inner membrane :** Cytochrome b,c_1,c,a, (cyt.b, cyt.c_1, cyt.c, cyt.a, cyt.a_3) NADH, dehydrogenase, succinate dehydrogenase, ubiquinone, flavoprotein, ATPase.

(3) **Perimitochondrial space :** Adenylate kinase, nucleoside diphosphokinase.

(4) **Inner matrix :** Pyruvate dehydrogenase, citrate synthase, aconitase, isocitrate dehydrogenase, fumarase, α – Ketoglutarate dehydrogenase, malate dehydrogenase.

Origin : Mitochondria are self-duplicating organelles due to presence of DNA molecules so new mitochondria are always formed by growth and division of pre-existing mitochondria by binary fission.

Functions

(1) Mitochondria are called power house or storage batteries or ATP mills formation of ATP is called oxidative phosphorylation.

(2) Intermediate products of cell respiration are used in the formation of steroids, cytochromes, chlorophyll, etc.

(3) These are also seat of some amino acid biosynthesis.

(4) Mitochondria also regulate the calcium ion concentration inside the cell.

(5) Site of thermiogenesis.

(6) Yolk nucleus (a mitochondrial cloud and golgi bodies) controls vitellogenesis.

(7) Mitochondria of spermatid form nebenkern (middle piece) of sperm during spermiogenesis.

(8) Mitochondria release energy during respiration.

(9) Mitochondria contain electron transport system.

Plastids

Plastids are semiautonomous organelles having DNA, RNA, Ribosomes and double membrane envelope. These are largest cell organelles in plant cell.

History

(1) Haeckel (1865) discovered plastid, but the term was first time used by Schimper (1883).

(2) A well organised system of grana and stroma in plastid of normal barley plant was reported by de Von Wettstein.

(3) Park and Biggins (1964) gave the concept of quantasomes.

(4) The term chlorophyll was given by Pelletier and Caventou, and structural details were given by Willstatter and Stall.

(5) The term thylakoid was given by Menke (1962).

(6) Fine structure was given by Mayer.

(7) Ris and Plaut (1962) reported DNA in chloroplast and was called plastidome.

Types of plastids : According to Schimper, Plastids are of 3 types: Leucoplasts, Chromoplasts and Chloroplasts.

Leucoplasts : They are colourless plastids which generally occur near the nucleus in nongreen cells and possess internal lamellae. Grana and photosynthetic pigments are absent. They mainly store food materials and occur in the cells not exposed to sunlight *e.g.*, seeds, underground stems, roots, tubers, rhizomes etc. These are of three types.

(1) **Amyloplast :** Synthesize and store starch grains. *e.g.*, potato tubers, wheat and rice grains.

(2) **Elaioplast (Lipidoplast, Oleoplast)** : They store lipids and oils *e.g.*, castor endosperm, tube rose, etc.

(3) **Aleuroplast (Proteinoplast) :** Store proteins *e.g.*, aleurone cells of maize grains.

Chromoplasts : Coloured plastids other than green are known as chromoplasts. These are present in petals and fruits. These also carry on photosynthesis. These may arise from the chloroplasts due to replacement of chlorophyll by other pigments.

Green tomatoes and chillies turn red on ripening because of replacement of chlorophyll molecule in chloroplasts by the red pigment lycopene in tomato and capsanthin in chillies. Thus, chloroplasts are changed into chromatoplast.

All colours (except green) are produced by flavins, flavenoids and cyanin. Cyanin pigment is of two types one is anthocyanin (blue) and another is erythrocyanin (red). Anthocyanin are water soluble pigments and found in cell sap of vacoule.

Chloroplast : Discovered by Sachs and named by Schimper. They are greenish plastids which possess photosynthetic pigments. Chloroplast are also known as factory for synthesis of sugars.

Number : It is variable. Number of chloroplast is 1 in *Spirogyra indica*, 2 in *Zygnema*, 16 in *S.rectospora*, upto 100 in mesophyll cells. The minimum number of one chloroplast per cell is found in *Ulothrix* and species of *Chlamydomonas*.

Shape : They have various shapes

Shape	Example
Cup shaped	*Chlamydomonas sp.*
Stellate shaped	*Zygnema.*
Collar or girdle shaped	*Ulothrix*
Spiral or ribbon shaped	*Spirogyra*
Reticulate/net like	*Oedogonium*
Discoid	*Voucheria*
Spherical	*Chlorella*
Biconvex/ovoid	Angiosperm

Size : It ranges from 3 – 10 μm (average 5 μm) in diameter. The discoid chloroplast of higher plants are 4 – 10 μm in length and 2– 4 μ m in breadth. Chloroplast of *Spirogyra* may reach a length of 1 *mm*. Sciophytes (Shade plant) have larger chloroplast.

Chemical composition : Proteins 50 – 60%; Lipids 25 – 30%; Chlorophyll – 5- 10 %; Carotenoids (carotenes and xanthophylls) 1 –2%; DNA – 0.5%, RNA 2 – 3%; Vitamins K and E; Quinines, Mg, Fe, Co, Mn, P, etc. in traces.

Ultrastructure : It is double membrane structure. Both membranes are smooth. The inner membrane is less permeable than outer but rich in proteins especially carrier proteins. Each membrane is 90 – 100 Å thick. The inter-membrane space is called the periplastidial space. Inner to membranes, matrix is present, which is divided into two parts.

(1) **Grana :** Inner plastidial membrane of the chloroplast is invaginated to form a series of parallel membranous sheets, called lamellae, which form a number of oval – shaped closed sacs, called thylakoids. Thylakoids are structural and functional elements of chloroplasts.

Along the inner side of thylakoid membrane, there are number of small rounded para-crystalline bodies, called quantasomes (a quantasome is the photosynthetic unit).

Park and Biggins (1964) discovered quantasomes. Each quantasome contains about 230 chlorophyll molecules (160 chl. '*a*' and 70 chl. '*b*') and 50 carotenoid molecules.

In eukaryotic plant cells, a number of thylakoids are superimposed like a pile of coins to form a granum. The number of thylakoids in a granum ranges from 10-100 (average number is 20-50). Adjacent grana are interconnected by branched tubules, called stromal lamellae or Fret-channel or Fret membrane's.

(2) **Stroma :** It is transparent, proteinaceous and watery substance. Dark reaction of photosynthesis occurs in this portion. Stroma is almost filled with "Rubisco" (about 15% of total enzyme, protein) enzyme CO_2 is accepted by this enzyme. CO_2 assimilation results in carbohydrate formation. It has 20 – 60 copies of naked circular double stranded DNA.

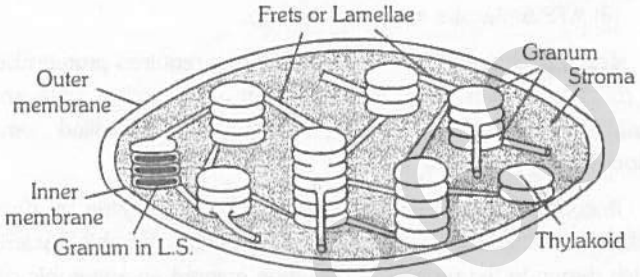


Fig : 3.1-5 A chloroplast in section (diagrammatic)

Pigments of chloroplast

Chlorophyll a : $C_{55}H_{72}O_5N_4Mg$ (with methyl group)

Chlorophyll b : $C_{55}H_{70}O_6N_4Mg$ (with aldehyde group)

Chlorophyll c : $C_{35}H_{32}O_5N_4Mg$

Chlorophyll d : $C_{54}H_{70}O_6N_4Mg$

Bacteriochlorophyll ($C_{55}H_{74}O_6N_4Mg$) or chlorobium chlorophyll present in photosynthetic bacteria. These pigment are red in acidic and blue in alkaline medium.

Carotenoids : These are hydrocarbons, soluble in organic solvents. These are of two types :

(1) **Carotenes :** $C_{40}H_{56}$ derivatives of vitamin A. Carrot coloured α, β, γ carotene, lycopene, etc. β - carotene most common.

(2) **Xanthophyll :** $C_{40}H_{56}O_2$, yellowish in colour, fucoxanthin, violaxanthin. Molar ratio of carotene and xanthophyll in young leaves is 2 : 1.

Origin of chloroplast : Plastids, like the mitochondria, are self duplicating organelles. These develop from colourless precursors, called proplastids. They are believed to be evolved from endosymbiont origination.

Functions

(1) It is the site of photosynthesis, (light and dark reaction).

(2) Photolysis of water, reduction of NADP to $NADPH_2$ take place in granum.

(3) Photophosphorylation through cytochrome b_6 f, plastocyanine and plastoquinone etc.

(4) They store starch or factory of synthesis of sugars.

(5) Chloroplast store fat in the form of plastoglobuli.

(6) They maintain the percentage of CO_2 and O_2 in atmosphere.

Endoplasmic reticulum (ER)

It is well developed electron microscopic network of interconnected cisternae, tubules and vesicles present throughout the cytoplasm, especially in the endoplasm.

Discovery : Garnier (1897) was first to observe the ergastoplasm in a cell. The ER was first noted by Porter, Claude, and Fullman in 1945 as a network. It was named by Porter in 1953.

Occurrence : The ER is present in almost all eukaryotic cells. A few cells such as ova, embryonic cells, and mature RBCs, however, lack ER. It is also absent in prokaryotic cell. In rapidly dividing cells endoplasmic reticulum is poorly developed.

Ultrastructure : The ER is made up of three components. All the three structures are bound by a single unit membrane.

(1) **Cisternae :** These are flattened, unbranched, sac like structures. They lie in stacks (piles) parallel to one another. They bear ribosomes. They contain glycoproteins named ribophorin-I and ribophorin-II that bind the ribosomes. Found in protein forming cells.

(2) **Vesicles :** These are oval or rounded, vacuole like elements, scattered in cytoplasm. These are also studded with ribosomes.

(3) **Tubules :** Wider, tubular, branched elements mainly present near the cell membrane. They are free from ribosomes. These are more in lipid forming cells.

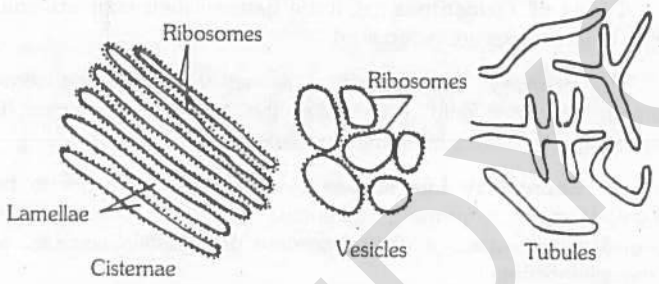


Fig : 3.1-6 Elements of Endoplasmic Reticulum

Types of ER : Depending upon the presence of ribosomes, the ER has been categorised into two types :

(1) **A smooth or Agranular endoplasmic reticulum (SER) :** It consists mainly of tubules and vesicles. It has no ribosomes associated to it. It is well developed in the muscle cells, adipose tissue cells, interstitial cells, glycogen storing liver cells, etc. and the cells that synthesize and secrete steroids. SER also takes part in synthesis of vitamins, carbohydrates and detoxification. It gives rise to sphaerosomes. It occurs in cells engaged in producing large quantity of lipids.

(2) **Rough or Granular endoplasmic reticulum (RER) :** It mainly consists of cisternae. It has ribosomes attached on its cytoplasmic surface. It is abundant in cells engaged in production and excertion of proteins, *e.g.*, plasma cells, goblets cells, pancreatic acinus cells and certain liver cells. The RER is more stable than SER. The RER is basophilic due to the presence of ribosomes. Ribosomes are attached to ER through hydrophobic interaction.

A third type annulate endoplasmic reticulum was discovered by Mecullo in 1972. It may be smooth or rough having pores like nuclear envelop.

Origin : RER is formed from nuclear membrane while SER is formed from RER by loss of ribosomes. Rough vesicles originate only from RER after homogenisation of cell. RER breaks in small fragments (Vesicles) and it is called microsome (This is not a cell organelle).

Functions

(1) Synthesis and secretion of specific proteins via – golgi bodies.

(2) Provides surface for synthesis of cholesterol, steroid, ascorbic acid, visual pigments and hormones *e.g.*, testosterone and estrogen.

(3) It helps in glycogenolysis in the liver cells and brings about detoxification (SER).

(4) ER is a component of cytoskeleton (Spread as a net) of cell and provides mechanical support and shape to the cell.

(5) ER acts as segregation apparatus and divides the cytoplasm into chambers. Compartmentalisation is most necessary for cellular life.

(6) It participates in the formation of cell-plate during cytokinesis in the plant cells by the formation of phragmoplasts.

(7) ER forms 30–60% part of total membranous system.

(8) It gives rise to vacoules.

(9) **Sarcoplasmic reticulum :** It is a modified SER striated muscle fibres (Veratti, 1902) which forms a network of interconnected tubules in the sarcoplasm. It helps in conduction of motor nerve impulses throughout the muscle fibre and in the removal of lactic acid so prevents muscle fatigue. It is called "Sarcoplasmic reticulum" in muscle and "Nissl'sgranules" in nerve cells, mylloid body in retinal cells.

Golgi complex

Golgi complex is made up of various membranous system *e.g.*, cisternae, vesicles and vacuoles. These are also called golgi bodies, golgisomes, lipochondrion, dictyosomes, Dalton complex, idiosomes or Baker's body and "traffic police" of the cell.

Discovery : First observed by George (1867) but it's morphological details were given by Camillo Golgi (1898), in nerve cells of barn owl and cat.

Occurence : It is present in all eukaryotic cells. *In plants*, these are scattered irregularly in the cytoplasm and called as "*dictyosomes*". These are absent in bacteria and blue green algae, RBCs, spermatozoa of bryophytes and pteridophytes, and sieve tube cells of phloem of angiosperm. The number of Golgi bodies/dictyosomes is generally 9 – 10 in a plant cell but is very high in cells engaged in secretory activity (*e.g.*, root cap cells). The number of golgi body is increased during cell division. Golgi body surrounded by a zone of protoplasm which is devoid of cell organelles called zone of exclusion (Morre, 1977).

Structure : Under transmission electron microscope the structure of golgibodies was study by Dalton and Felix (1954), golgi body is made of 4 parts.

(1) **Cisternae :** Golgi apparatus is made up of stack of flat sac like structure called cisternae. The margins of each cisterna are gently curved so that the entire golgi body takes on a cup like appearance. The golgi body has a definite polarity. The cisternae at the convex end of the dictyosome comprises forming face (F. face) or cis face. While the cisternae at the concave end comprises the maturing face (M. face) or trans face. The forming face is located next to either the nucleus or endoplasmic reticulum. The maturing face is usually directed towards the plasma membranes. It is the functional unit of golgi body.

(2) **Tubules :** These arise due to fenestration of cisternae and it forms a complex network.

(3) **Secretory vesicles :** These are small sized components each about 40 Å in diameter present along convex surface of edges of cisternae. These are smooth and coated type of vesicles.

(4) **Golgian vacuoles :** They are expanded part of the cisternae which have become modified to form vacuoles. The vacuoles develop from the concave or maturing face. Golgian vacuoles contain amorphous or granular substance. Some of the golgian vacuoles function as lysosomes.

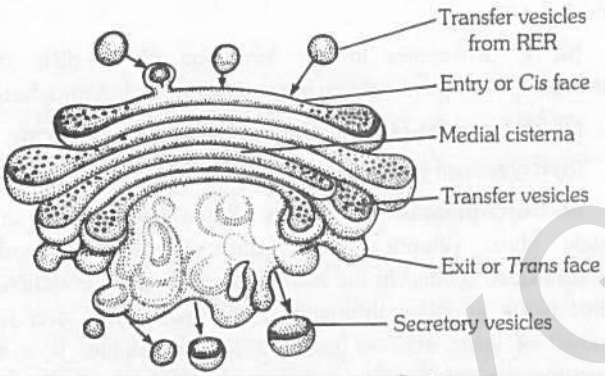


Fig : 3.1-7 Structure of Golgi complex

Origin : Most accepted view is that golgi body originates from RER-that has lost its ribosomes from this RER arise transport vesicles that contain Golgi membrane and fuse with the saccule on the forming face of Golgi apparatus. This is why this face is called the forming face.

Functions

(1) The main function of golgi body is secretion, so it is large sized among the secretory cells.

(2) Glycosidation of lipids *i.e.*, addition of oligosaccharides to produce glycolipids.

(3) Glycosylation of proteins *i.e.*, addition of carbohydrate to produce glycoproteins.

(4) Formation of primary lysosomes.

(5) Golgi body forms the cell plate. During cell division by secreting hemicellulose formation of enzyme and hormones (Thyroxine) etc.

(6) In oocytes of animal, golgi apparatus functions as the centre around which yolk is deposited *i.e.*, vitellogenesis.

(7) Membrane of the vesicles produced by golgi apparatus join in the region of cytokinesis to produce new plasmalemma.

(8) It is also called export house of cell.

(9) Golgi body contains phospholipids, proteins, enzymes and vitamin.

(10) The golgi complex gives rise to the acrosome in an animal sperm.

Lysosomes

Lysosomes are electron microscopic, vesicular structures of the cytoplasm, bounded by a single membrane (lipoproteinous) which are involved in intracellular digestive activities, contains hydrolytic enzymes, so called lysosomes.

Discovery

(i) These were first discovered by a Belgian biochemist, Christian de Duve (1955) in the liver cells and were earlier named pericanalicular dense bodies.

(ii) Term Lysosome was given by Novikoff under the study of electron microscope.

(iii) Matile (1964) was first to demonstrate their presence in plants, particularly in the fungus *Neurospora*. Polymorphism in lysosomes were described by De Robertis *et. al* (1971).

Occurrence : These are absent from the prokaryotes but are present in all eukaryotic animal cells except mammalian RBCs. They have been recorded in fungi, *Euglena*, cotton and pea seeds.

Shape : These are generally spherical in shape but are irregular in plant root tip cells.

Size : Size range is 0.2-0.8 μm while size is 0.5 μm (500 nm).

Types of Lysosomes : On the basis of their contents, four types of lysosomes are recognised.

(1) **Primary Lysosomes :** A newly formed lysosome contains enzymes only. It is called the *primary lysosomes*. Its enzymes are probably in an inactive state.

(2) **Secondary Lysosomes :** When some material to be digested enters a primary lysosome, the latter is named the secondary lysosome, or *phagolysosome* or *digestive vacuole*, or heterophagosome.

(3) **Tertiary lysosomes/Residual bodies :** A secondary lysosome containing indigestible matter is known as the *residual bodies* or *tertiary lysosome*. The latter meets the cell by *exocytosis* (*ephagy*).

(4) **Autophagosomes/Autolysosomes :** A cell may digest its own organelles, such as mitochondria, ER. This process is called autophagy. These are formed of primary lysosomes. The acid hydrolases of lysosomes digest the organelles thus, it is called autophagosome. The lysosome are sometimes called disposal units/suicidal bags. Sometime they get burst and causes the destruction of cell or tissue.

Chemical composition : Matrix of primary lysosome is formed of hydrolases, which is involved in hydrolysis or polymeric compounds, that operate in acidic medium at *pH* 5, so called acid hydrolases. Upto now 50 types of enzyme have been reported. These are as :

Proteases (cathepsin and collagenase), Nucleases (DNAse and RNAse), Glycosidases (β-galactosidase, β-glucoronidase), Phosphatases (ATPase, acid phosphatase /marker enzyme).

Functions

(1) Lysosomes of sperms provide enzyme for breaking limiting membrane of egg *e.g.*, hyaluronidase enzyme.

(2) Lysosomes functions as trigger of cell division or initiate cell division by digesting repressor molecules.

(3) Nucleases (DNAse) of lysosomes may cause gene mutations which may cause disease like leukemia or blood cancer (partial deletion of 21st chromosome).

(4) Sometimes residual bodies accumulate inside the cells leading to storage diseases *e.g.*, a glycogen storage disease called Pompe's disease, polynephritis Hurler's disease (deformed bones due to accumulation of mucopolysaccharides).

(5) Lysosomes also engulf the carcinogens.

Ribosome

The ribosomes are smallest known electron microscopic without membrane, ribonucleo–protein particles attached either on RER or floating freely in the cytoplasm and are the sites of protein synthesis.

Discovery : In 1943 *Claude* observed some basophilic bodies and named them as microsome. *Palade* (1955) coined the term ribosome (form animal cell). Ribosomes in nucleoplasm were observed by *Tsao* and *Sato* (1959). First isolated by Tissieres and Watson (1958) from *E. coli*. Ribosomes found in groups are termed as polyribosomes or ergosomes (*Rich* and *Warner* 1963 observed first time polyribosomes).

Occurrence : In prokaryotes ribosomes are found only in free form in the cytoplasm. While in the eukaryotes the ribosomes are found in two forms in the cytoplasm, free form and bind form (bound on RER and outer nuclear membrane). These are also reported inside some cell organelles like mitochondria and plastids respectively called mitoribosomes and plastidoribosomes.

Types of ribosomes

(1) **70S ribosomes :** Found in prokaryotes, mitochondria and plastid of eukaryotes.

(2) **80S ribosomes :** Found in cytoplasm of eukaryotes.

(3) **77S, 60S and 55S ribosomes :** Levine and Goodenough (1874) observed 77S ribosomes in fungal mitochondria 60S ribosomes in animal mitochondria and 55S in mammalian mitochondria.

Structure : Each ribosome is formed of two unequal subunits, which join only at the time of protein synthesis. In 70S and 80S ribosomes, 50S and 30S, 60S and 40S are larger and smaller subunits respectively. Larger subunits is dome shaped and attached to ER by glycoproteins called "ribophorins".

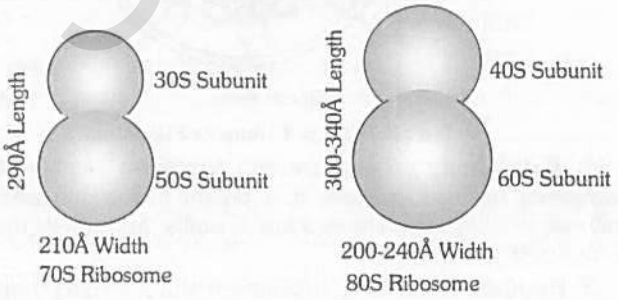


Fig : 3.1-8 Structure of 70S and 80S ribosome

Smaller subunit is oval shaped and fits as a cap on flat side of larger subunit. Ribosomes are attached to ER through hydrophobic interactions.

Chemical composition : Ribosomes are chemically composed of rRNA and proteins Ribonucleo-Protein (RNP). 70*S* ribosomes has 60-65% rRNA and 35-40% proteins (ratio is 2:1). rRNAs are of three types : 23*S* type and 5*S* type rRNAs in 50*S* and 16S type rRNA in 30S sub-units.

80*S* ribosome has 45% rRNA and 55% proteins (ratio is about 1 : 1). r-RNA are of four types : 28*S*, 5*S* and 5.8*S* types of rRNAs in 60*S* and 18*S* type rRNA in 40*S* sub-units.

A 1×10^{-3} (0.001 *M*) molar concentration of Mg^{++} is needed for the structural cohesion of ribosomes *i.e.*, for holding the two subunits together. If this concentration is increased by ten folds, two ribosomes unite to form a *dimer*. By decreasing the Mg^{++} conc. to normal, the dimer breaks into monomers (single ribosomes).

Biogenesis of ribosome

(1) In eukaryotes the ribosomal RNAs like 18S, 5.8S and 28S are synthesized by nucleolus and 5S RNA out of the nucleus.

(2) In prokaryotes both rRNA and its protein are synthesized as well as assembled by cytoplasm.

Polyribosomes or Polysomes : When many ribosomes (generally 6 – 8) are attached at some mRNA strand. It is called polysome. The distance between adjacent ribosomes is of 90 nucleotides. These are functional unit of protein synthesis.

Functions

(1) Ribosomes are also called protein factories of the cell or work branch of proteins.

(2) Free ribosomes synthesize structural proteins and bounded ribosomes synthesize proteins for transport.

(3) Ribosomes are essential for protein synthesis.

(4) Help in the process of photosynthesis.

(5) Enzyme peptidyl transferase occurs in large subunit of ribosome which helps in protein synthesis.

(6) Newly formed polypeptide is protected from degradation by cytoplasmic enzymes in large sub-unit of ribosomes before releasing it into RER lumen.

Microbodies

(1) **Sphaerosomes**

Discovery : These were first observed by Hanstein (1880) but discovered by Perner (1953). Term sphaerosomes was given by Dangeard.

Occurrence : Sphaerosomes, arise from the E.R. These are found in all the plant cells which involves in the synthesis and storage of lipids *i.e.*, endosperm and cotyledon of oil seeds.

Shape, size and structure : These are spherical or oval in shape about 0.5-2.5 μm in diameter. They contain hydrolytic enzymes like protease, ribonuclease, phosphatase, esterase etc. They are bounded by a single unit membrane.

Function : The main function of sphaerosomes is to help in lipid metabolism. These are also known as plant lysosomes.

(2) **Peroxisomes (Uricosomes)**

Discovery : These were discovered by Tolbert (1969). De Duve (1965) isolated certain sac like organelles from various types of animals and plants. These were called peroxisomes because these contain peroxide producing enzymes (oxidases) and peroxide destroying enzymes (catalases).

Occurrence : These are found in photosynthetic cells of plants. In animals peroxisomes are found in vertebrates (cells of liver, kidney), brain, small intestine, testis and adrenal cortex), invertebrates and protozoans *e.g.*, Paramecium.

Shape, size and structure : These are spherical in shape, about 1.5 μm in size. They are bounded by a single unit membrane.

Their membrane is permeable to amino acids, uric acids, etc. They contain four enzymes of H_2O_2 metabolism. The enzymes urate oxidase, *d*-amino oxidase, α-hydroxy acid oxidase produce H_2O_2 whereas the catalases plays a significant protective role by degrading H_2O_2 because H_2O_2 is toxic for cells.

Function : These are involved in the formation and degrading of H_2O_2. Plant peroxisomes are also involved in photorespiration.

(3) **Glyoxysomes**

Discovery : These were discovered by Beevers in 1961 and Briedenbach in 1967.

Occurrence : These are found in fungi, some protists and germinating fatty seeds where insoluble lipid food reserves must be turned into soluble sugars. Absent in animal cell.

Shape, size and structure : These are spherical in shape, about 0.5-1μm in size, they contain enzymes of metabolism of glycolic acid via glyoxylate cycle and bounded by a unit membrane. These also contain enzymes for β-oxidation of fatty acids. Produced acetyl CoA. The latter is metabolised in glyoxlate cycle to produce carbohydrates.

Functions : The main function of glyoxysomes is conversion of fats into carbohydrates.

(4) **Lomasomes :** These are sac like structures found between cell wall and plasmalemma in the haustoria of fungal hyphae. These were discovered by *Moore* and *McAlear* (1961). Webster called them border bodies.

Centrosome

Discovery : Centrosome was first discovered by Van Benden (1887). Term and structure was given by T. Boweri.

Occurrence : It is found in all the animal cell except mature mammalian RBC's. It is also found in most of protists and motile plant cells like antherozoids of ferns, zoospores of algae and motile algal forms *e.g.*, Chlamydomonas but is absent in prokaryotes, fungi, gymnosperms and angiosperms.

Structure : Centrosome is without unit membrane structure. It is formed of two darkly *stained granules called* centrioles, which are collectively called diplosome. These centrioles are surrounded by a transparent cytoplasmic area called centrosphere or Kinetoplasm. Centriole and centrosphere are collectively called centrosome. Each centriole is a microtubular structure and is formed of microtubules arranged in 9+0 manner (all the 9 microtubules are peripheral in position). Inside the microtubules, there is an intra-centriolar or cart-wheel structure which is formed of a central hub (about 25Å in diameter) and 9 radial spokes or radial fibres.

Chemical composition : Centrosome is lipoproteinaceous structure. The microtubules of centriole are composed of protein tubulin and some lipids. They are rich in ATPase enzyme.

Origin : The daughter centriole is formed from the pre-existing centriole in G_2 of interphase so called self-replicating organelle.

Functions

(1) The centrioles help organising the spindle fibres and astral rays during cell division.

(2) They provide basal bodies which give rise to cilia and flagella.

Cilia and Flagella

Discovery : Flagellum presence was first reported by *Englemann* (1868). *Jansen* (1887) was first scientist to report the structure of sperm flagellum.

Definition : Cilia and flagella are microscopic, hair or thread-like motile structures present extra-cellularly but originate intra-cellularly from the basal body.

Occurrence : Cilia are found in all the ciliate protozoans *e.g.*, Paramecium, *Vorticella* etc.

Flagella are found in all the flagellate protozoans *e.g.*, *Euglena, Trichonympha* etc.

Structure : Both cilia flagella are structurally similar and possess similar parts-basal body, rootlets, basal plate and shaft.

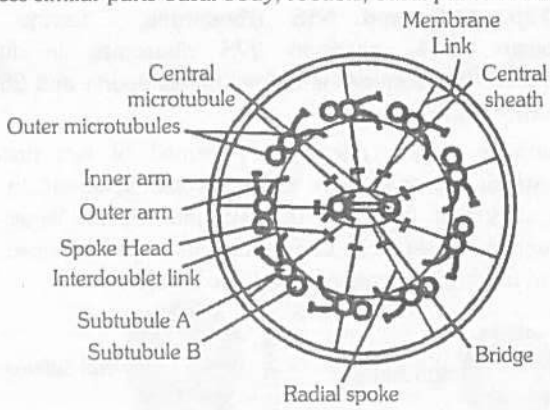


Fig : 3.1-9 T.S. Cilium or Flagellum

(1) **Basal body :** These are also termed as blepharoplast (kinetosome) or basal granule. It is present below the plasma membrane in cytoplasm. The structure is similar to centriole made of 9 triplets of microtubules.

(2) **Rootlets :** Made of microfilament and providing support to the basal body.

(3) **Basal plate :** Central fibril develop in this area. It is highly dense and lie above plasma-membrane. The basal body and the shaft at the level of plasma membrane.

(4) **Shaft :** It is the hair like projecting part of cilia and flagella which remains outside the cytoplasm. It has 9 doublet of microtubules in radial symmetry. These are called axonema. Each axonema has 11 fibrils, 9 in the periphery and 2 in the centre. The arrangement is called 9 + 2 pattern.

Chemical composition : Chemically, the central tubules are formed of dynein protein while the peripheral microtubules are formed of tubulin protein.

Type of flagella : There are two types of flagella.

(1) **Tinsel type :** In this, flagellum has lateral hair-like processes, called flimmers or mastigonemes.

(2) **Whiplash type :** In this, flagellum has no flimmers.

Functions

(1) They help in locomotion, respiration, cleaning, circulation, feeding, etc.

(2) Being protoplasmic structure they can function as sensory organs.

(3) They show sensitivity to changes in light, temperature and contact.

Table : 3.1-5 Difference between cilia and flagella

Cilia	Flagella
More in number (may be upto 14,000 per cell).	Less in number (1-8).
Small sized (5-10 μm).	Large sized (upto 100-200 μm).
Generally distributed on whole body.	Generally located at anterior end of body.
Beat in either metachronous or synchronous coordination.	Beat independently.
Sweeping or rowing motion.	Undulatory motion.
Locomotion, feeding, circulation, etc.	Only locomotion.

Cytoskeleton

In eukaryotic cell, a framework of fibrous protein elements became necessary to support the extensive system of membranes. These elements collectively form cytoskeleton of the cell. There are of three types.

(1) **Microtubules :** These were first discovered by De Robertis and Franchi (1953) in the axons of medullated nerve fibres and were named neurotubules. The term was coined by Slautterback (1963).

Position : The microtubules are electron-microscopic structures found only in the eukaryotic cellular structures like cilia, flagella, centriole, basal-body, astral fibres, spindle fibres.

Structure : A microtubule is a hollow cylindrical structure of about 250 Å in diameter with about 150 Å luman. Its wall is about 50Å thick. Its walls is formed of 13 parallel, proto-tubules.

Chemical composition : These are mainly formed of tubulin protein. A tubulin protein is formed of 2 sub-units : α – tubulin molecule and β – tubulin molecule which are alternatively in a helical manner.

Functions

(1) These form a part of cytoskeleton and help in cell-shape and mechanical support.

(2) The microtubules of cilia and flagella help in locomotion and feeding.

(3) The microtubules of asters and spindle fibres of the mitotic apparatus help in the movement of chromosomes towards the opposite poles in cell-division.

(2) **Microfilament**

Discovery : These were discovered by Paleviz et. al. (1974).

Position : These are electron-microscopic, long, narrow, cylindrical, non-contractile and proteins structures found only in the eukaryotic cytoplasm. These are present in the microvilli, muscle fibres (called myofilaments) etc. But these are absent in prokaryotes.

Structure : Each microfilament is a solid filament of 50-60 Å diameter and is formed of a helical series of globular protein molecules. These are generally grouped to form bundles.

Chemical composition : These are mainly formed of actin-protein (contractile).

Functions

(1) The microfilaments forms a part of cytoskeleton and change the cell shape during development, motility and division.

(2) The microfilaments bring about directed movements of particles and organelles along them in the cell.

(3) The microfilaments also produce streaming movements of cytoplasm.

(4) The microfilaments are responsible for the movement of cell membrane during endocytosis and exocytosis.

(3) **Intermediate filaments**

Location : They are supportive elements in the cytoplasm of the eukaryotic cells. They are missing in mammalian RBCs.

Structure : The IFs are somewhat larger than the microfilaments and are about 10 *nm* thick. They are solid, unbranched and composed of nonmotile structural proteins, such as keratin, desmine, vimentin.

Functions

(1) They form a part of cytoskeleton that supports the fluid cytosol and maintains the shape of the cell.

(2) They provided strength to the axons.

(3) They keep nucleus and other organelles in place.

Nucleus

The nucleus also called director of the cell. It is the most important part of the cell which directs and controls all the cellular function.

Discovery : The nucleus was first observed by *Robert Brown* (1831), in orchid root cells. Nucleus plays determinative (in heredity) role in cell and organism, that was experimentally demonstrated by *Hammerling* (1934) in surgical experiments with green marine unicelled algae *Acetabularia*.

Occurence : A true nucleus with definite nuclear membrane and linear chromosome, is present in all the eukaryotes except mature mammalian RBCs, sieve tube cell of phloem, tracheids and vessels of xylem. The prokaryotes have an incipient nucleus, called nucleoid or prokaryon or genophore or false nucleus.

Number : Usually there is a single nucleus per cell *i.e.*, mononucleate condition, *e.g.*, *Acetabularia*.

(1) **Anucleate (without nucleus) :** RBCs of mammals, phloem sieve tube, trachids and vessels of xylam.

(2) **Binucleate :** *e.g.*, Ciliate, Protozoans like Paramecium.

(3) **Polynucleate :** *e.g.*, fungal hyphae of *Rhizopus*, *Vaucheria*. Polynucleate condition may be because of fusion of a number of cells. *i.e.*, syncytium, coconut endosperm or by free nuclear divisions without cytokinesis *i.e.*, coenocyte.

Shape : It varies widely, generally spherical *e.g.*, cuboidal germ cells, oval *e.g.*, columnar cells of intestine, bean shaped in *paramecium*, horse-shoe shaped in *Vorticella*, bilobed, *e.g.*, WBCs (acidophils), 3 lobed *e.g.*, basophil, multilobed *e.g.*, neutrophils, long and beaded form (moniliform) *e.g.*, stentor and branched in silk spinning cells of platy phalyx insect larva.

Size : The size of nucleus is variable *i.e.*, 5 – 30μ. In metabolically active cells size of the nucleus is larger than metabolically inactive cells.

Chemical composition

Proteins = 80%, DNA = 12%, RNA= 5%, Lipids = 3%

Enzymes like polymerases are abundantly present and help in synthesis of DNA and RNA.

Ultrastructure : The nucleus is composed of following structure.

(1) **Nuclear membrane :** It is also called nuclear envelope or nucleolemma or karyotheca, was first discovered by *Erclab* (1845).

Structure : It is a bilayered envelope. Each membrane is about 60-90Å thick lipoproteinous and trilaminar. Outer membrane, called ectokaryotheca (with ribosome) and inner membrane is called endokaryotheca (without ribosome). Two membranes are separated by a fluid-filled intermembranous perinuclear space (about 100-300Å).

Nuclear membrane is porous and has 1,000-10,000 octagonal nuclear pores. Each nuclear pore is about 400-1,000 Å in diameter (average size is 800 Å). Callan and Tamlin (1950) first to observe nuclear pore in nuclear membrane. The nuclear pores are enclosed by circular structure are called annuli. The pore and annuli together are called pore complex or pore basket.

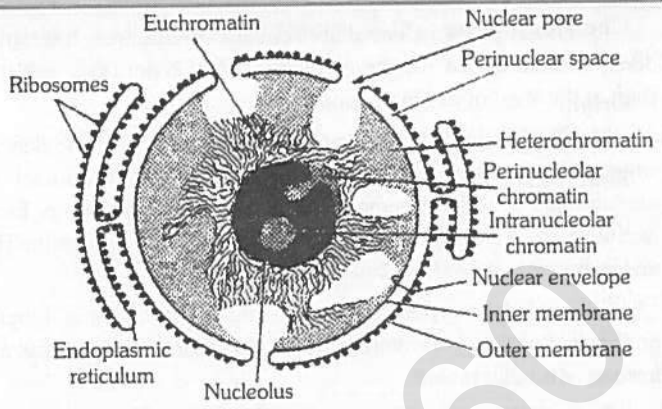


Fig : 3.1-10 Electron microscopic structure of nucleus

Origin : It is formed by the fusion of ER elements during the telophase of cell division.

Functions

(i) It regulates the nucleo-cytoplasmic interactions.

(ii) It allows the passage of inorganic ions, small organic molecules, ribosomal subunits, RNAs and proteins through nuclear pores.

(iii) It maintains the shape of the nucleus.

(2) **The nucleolus (Little nucleus plasmosome) :** It was first observed by *Fontana* (1781) in the skin cells of an eel. Bowman (1840) coined term 'nucleolus'. Wagner (1840) gave its light microscopic structure.

Position : It is generally associated with nucleolar organizer region (NOR) of the nucleolar chromosomes. It is absent in muscle fibres, RBC, yeast, sperm and prokaryotes.

Number : Generally, a diploid cell is with two nucleoli but there are five nucleoli in somatic cell of man and about 1000 nucleoli in the oocytes of Xenopus.

Structure : (*De Robertis et.al* 1971). A nucleolus is distinguishable into following regions :-

(1) **Chromatin :** The nucleolus is surrounded by perinucleolar chromatin.

(2) **Pars fibrosa :** Fibrils of 80 – 100 Å size form a part of the nucleolus.

(3) **Pars granulosa :** Granules of 150 – 200 Å diameter constitute the granular part of the nucleolus. Ribosome formation takes place in this part so it is called assembly line of ribosome.

(4) **Pars amorpha :** The granules and the fibrils lie dispersed in an amorphous proteinaceous matrix. Nucleolus is stained by "pyronine". It is not bounded by any limiting membrane.

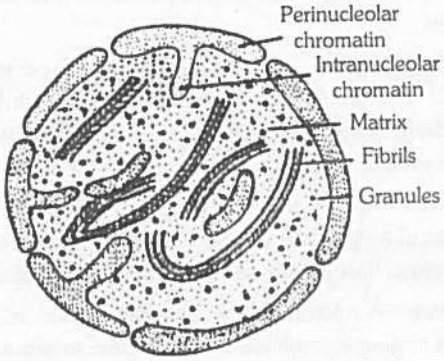


Fig : 3.1-11 Ultrastructure of a Nucleolus

Chemical composition : Nucleolus is mainly formed of RNA and non histone acidic proteins. It is a store house of rRNA.

Origin : A nucleolus is formed at specific sites, called the nucleolar organizers, present on certain chromosomes region (NOR).

Functions

(i) It is seat of biogenesis of rRNA and also stores rRNA.

(ii) It plays important role in spindle formation during cell division.

(iii) It receives the ribosomal proteins from the cytoplasm, combines the rRNAs and ribosomal proteins to form ribosomal subunits. So it is also called ribosome producing machine or factory.

(3) **Nucleoplasm :** It is also called karyolymph. It is transparent, homogenous, semifluid, colloidal, ground substance present inside the nuclear membrane. It contains Nucleic acid (DNA and RNA), Proteins (Basic proteins and acidic protein), Enzyme (DNA and RNA polymerase, NAD synthetase etc.), Minerals (*K, Na, Ca, Mg* etc.) and Ribonucleoproteins.

The nucleoplasm helps in maintaining the shape of nucleus formation of spindle protein of NAD, ATP, DNA, RNAs and ribosomal subunits. Plasmosome and karyosome combindly called "*amphinucleoli*".

(4) **Chromatin fibres /Nuclear chromatin :** The nucleoplasm contains many thread like, coiled and much elongated structures which take readily the basic stains such as "basic fuchsine". These thread like structures are known as chromatin fibre. They are uniformly distributed in the nucleoplasm. They are observed only in the "interphase stage".

(5) **Nuclear matrix :** It is network of proteinaceous fibrils. It is outer thicker part is called fibrous lamina (Haris and James, 1952).

Chromosome (Gr. chroma = colour soma = body)

Chromosome were discovered by Hofmeister (1848) in filament of pollen mother cells of tradescantia (Rhoeodiscolour) studied by strasburger (1875) and given the present name by Waldeyer (1888).

During interphase, chromatin threads are present in the form of a network called chromatin reticulum. At the time of cell division, these thread like structures of chromatin become visible as independent structures, called chromosomes. The haploid set of chromosomes is defined as genome.

Structure : Each chromosome consists of two coiled filaments throughout its length called chromonemata by Vejdovsky. These have bead like structures called chromomeres which bear genes. Chromatid is a half chromosome or daughter chromosome. The two chromatids are connected at the centromere or primary constriction. Primary constriction (centromere) and secondary constriction gives rise to satellite. The secondary constriction consists of genes which code for ribosomal RNA and nucleolus hence it is called as "nucleolar organizer region". Chromosomes having satellite are called SAT chromosomes. The ends of chromosomes are called "telomeres" (which do not unite with any other structure).

In 1928 *Emile Heitz* developed a technique for stainning of chromosomes. Staining property of chromosomes is called as heteropycnosis. Chromosomes can be stained with basic dye like janus green there are two types of regions –

(1) **Heterochromatin :** It is formed of thick regions which are more darkly stained than other areas. It is with condensed RNA which is transcriptionally inactive and late replicating. It generally lies near the nuclear lamina. It is of two type :

(i) **Constitutive hetrochromative :** Occurs in all cells in all stages. *e.g.*, Centromere.

(ii) **Facultative hetrochromative :** Formed by inactivation of some gene in some cell in some stages. *e.g.*, Barr body.

(2) **Euchromatin :** It is true chromatin and is formed of thin, less darkly stained areas. It is with loose DNA which is transcriptionally active and early replicating.

Chemical Composition : DNA - 40%. Histone – 50%. Other (acid) Proteins – 8.5%. RNA – 1.5%. Traces of lipids, *Ca, Mg* and *Fe*. Histone are low molecular weight basic proteins which occur alongwith DNA in 1 : 1 ratio. Nonhistone chromosomal or NHC proteins are of three types– structural, enzymatic and regulatory. Structural NHC proteins form the core or axis of the chromosome. They are also called scaffold proteins.

Metabolically inactive cell inclusions

Within the cytoplasm of a cell there occur many different kinds of non-living structures which are called inclusions or ergastic / Deutoplasmic substances.

(1) **Vacuoles :** The vacuole in plants was discovered by *Spallanzani*. It is a non-living reservoir, bounded by a differentially or selectively permeable membrane, the tonoplast. The vacuole is filled with cell sap or tonoplasm. This cell sap is generally neutral but at maturity it becomes acidic. They contain water, minerals and anthocyanin pigments. These pigments are responsible for the different colours of flowers.

Some protozoans have contractile vacuoles which enlarge by accumulation of fluid or collapse by expelling them from the cell. The vacuoles may be sap vacuoles, contractile vacuoles or gas vacuoles (pseudo vacuoles).

Function of vacuoles : Vacuole maintains osmotic relation of cell which is helpful in absorption of water. Turgidity and flaccid stages of a cell are due to the concentrations of sap in the vacuole.

(2) **Reserve food material**

The reserve food material may be classified as follows :

(i) **Carbohydrates :** Non-nitrogenous, soluble or non-soluble important reserve food material. Starch cellulose and glycogen are all insoluble.

(a) **Starch :** Found in plants in the form of minute solid grains. Starch grains are of two types :

Assimilation starch : It is formed as a result of photosynthesis of chloroplasts.

Reserve starch : Thick layers are deposited around an organic centre called hilum.

(b) **Glycogen :** Glycogen or animal starch occurs only in colourless plants like fungi.

(c) **Inulin :** It is a complex type of polysaccharide, soluble and found dissolved in cell sap of roots of Dahlia, Jaruslem, Artichoke, Dandelion and members of compositae.

(d) **Sugars :** A number of sugars are found in solution of cell sap. These include glucose, fructose, sucrose, etc.

(e) **Cellulose :** Chemical formula is $(C_6H_{10}O_5)_n$. The cell wall is made up of cellulose. It is insoluble in water.

(ii) **Fats and Oils :** These are important reserve food material. These are always decomposed into glycerol and fatty acids by enzymatic action. Fat is usually abundant in cotyledons than in the endosperm. *e.g.*, flax seed produce linseed oil, castor produce castor oil, cotton seeds produce cottonseed oil, etc.

(iii) **Proteins and Amides (Aleurone grains) :** Storage organ usually contain protein in the form of crystalline bodies known as crystalloids (potato). Proteins may be in the form of aleurone grains as in pea, maize, castor, wheat, etc.

(3) **Excretory Products :** The organic waste products of plants are by-product of metabolism. They are classified as :

(i) **Resins :** They are believed to be aromatic compounds consisting of carbon, hydrogen and oxygen and are acidic in nature. Sometimes they are found in combination with gums and are called gum resin. *e.g.*, *Asafoetida* (heeng).

(ii) **Tannins :** They are complex nitrogenous compounds of acid nature having an astringent taste. Presence of tannin in plants makes its wood hard durable and germ proof.

(iii) **Alkaloids :** These are organic, basic, nitrogenous substance. They occur in combination with organic acids and most of them are poisonous. From plants, cocaine, hyoscine, morphine, nicotine, quinine, atropine, strychnine and daturine etc. are extracted.

(iv) **Glucosides** : Some glucosides or glycosides function as storage substance *e.g.*, amygdaline of the bitter almond.

(v) **Etherial and Essential oils** : These consist mixture of various hydrocarbons known as tarpenes and their oxygen derivatives. They are responsible for flavour of many fruits and scent of many flowers etc. They are volatile and are soluble in water, ether, petroleum etc. *e.g.*, lavender, mint, clove oil, eucalyptus oil, theme oil etc.

(vi) **Mineral matter :** Many minerals are waste products in plants.

(a) **Calcium oxalate :** It occurs in the form of crystals of various shapes.

Raphides : Needle shaped crystals are known as raphides. *e.g.*, in plants like jamikand, *Asparagus, Colocasia*, water hyacinth (Jal kumbhi) etc.

Rosette or Sphaeraphides : Star shaped crystals. They occur in special mucilaginous parenchyma cells of the petiole of arum, water hyacinth, etc. Crystals in the form of cubes are found in tunic of onion bulb. In the leaf of belladona, these crystals are in the form of sand and also called as sand crystals.

Calcium oxalate crystals : In members of family solanaceae. They are found as cubics, rods and prisms.

(b) **Calcium carbonate :** It is deposited in the form of crystalline masses hanging from a cellulose stalk in enlarged epidermal cells of leaves of *Ficus elastica* (Indian rubber plant) and is called as cystolith.

(vii) **Latex :** It is an emulsion in water having many substances either in suspension or in true solution. It may contain sugars, alkaloids and oils. It is watery in banana, milky white in *Euphorbia*, yellow or orange red in opium (poppy) is dried latex.

(viii) **Organic acids :** Tartaric acid in tamarind, and grapes, citric acid in lemon, orange etc. malic acid in apple and *Bryophyllum*. Oxalic acid in the form of crystals.

(ix) **Gums :** It is formed by decomposition of cellulose cell wall. Gum arabic of commerce is obtained from *Acacia senegal*.

Tips & Tricks

- HPLC stands for high performance liquid chromatography.
- Three dimensional image are obtained with the help of scanning electron microscope and X-ray microscope. Where as all other microscopes give two dimensional image
- Tracer isotopes / radioactive isotopes : Which functions like normal elements but emit radiations. They can, therefore, be located by Geiger muller counter or scintillalion counter and autoradiography, *e.g.*, ^3H, ^{14}C, ^{32}P, ^{35}S, etc.
- The smallest cell considered so far is of PPLO (Pleuropneumonia like organisms) or Mycoplasma gallisepticum *i.e.*, 0.1μ.
- Negative charge of the membrane is due to N – acetyl neuraminic acid (NANA)/sialic acid.
- Transosomes found in follicular cells of ovary of birds and have triple unit membrane. First reported by Press (1964).
- Nehar and Sakmann discovered ion-channels in plasma membrane and they were awarded Noble prize for it in 1971.
- Singer and Nicolson's model differs from Robertson's model in the arrangement of proteins.
- Petite character in yeast and cytoplasmic male sterility in maize are examples of mitochondrial inheritance.
- Lehninger discovered oxysomes.
- In prokaryotic cell, plasma membrane infolding makes a structure mesosome. Which is analogous structure of mitochondria of eukaryotic cell (both part in respiration).
- Chromatophore term was given by Schmitz.
- Autonomic genome system is present in Mitochondria and chloroplast.
- In confocal microscope, the specimen is illuminated by laser beam.

Ordinary Thinking

Objective Questions

Tools and Technique

1. Differentiation capacity of compound microscope is **[RPMT 1999]**

(a) 0.275 μm (b) 2.75 μm

(c) 27.5 μm (d) None

2. 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 cathode to anode sides of the gel would be **[DUMET 2010]**

(a) b, a, c, d (b) a, b, c, d

(c) c, b, a, d (d) b, a, d, c

3. A student wishes to study the cell structure under a light microscope having $10X$ eyepiece and $45X$ objective. He should illuminate the object by which one of the following colours of light so as to get the best possible resolution **[CBSE PMT 2005; WB JEE 2008]**

(a) Blue (b) Green

(c) Yellow (d) Red

4. Electron microscope is used for **[Kerala CET 2003]**

(a) Viewing structure of the cell

(b) Whole mount study

(c) Cell division study

(d) Structure of the pollen grain

5. A magnification of upto 100 million times is possible in **[CBSE PMT 2000; KCET 2001]**

(a) Scanning electron microscope

(b) Electron transmission microscope

(c) Scanning probe microscope

(d) Photon tunneling microscope

6. Resolving power of light microscope is **[DPMT 2003]**

(a) 0.2 μm (b) 0.1 μm

(c) 2 μm (d) 100 μm

7. Electron microscope has revealed the presence of **or** Which among the following can be seen only under electron microscope **[AFMC 1996; MP PMT 1998]**

(a) Ribosome (b) Chromosome

(c) Chloroplast (d) Leucoplast

8. Who invented the "electron microscope" **[AFMC 2001; BVP 2002; AIIMS 2003; HPMT 2005; MP PMT 2007]**

(a) Knoll and Ruska (b) Robert Brown

(c) Correns (d) Janssen and Janssen

9. Which of the following statements is/are true

A. The resolution power of unaided human eye is 100 micrometre

B. The highest resolution is obtained with the light of shortest wavelength

C. Dark field microscope is most useful for viewing the living cells

D. Chromatography is the method of separation of molecular components of the cells present in cytosol

E. In gel filtration chromatography, molecules can be separated in picogram to nanogram quantities **[Kerala PMT 2008]**

(a) A, C and D only (b) B and D only

(c) C and E only (d) C, D and E only

(e) A, B and D only

10. 1 nm is equal to **[CPMT 1999; JIPMER 2001]**

(a) 10 $\AA$ (b) 10^{-3} mm

(c) 10^{-8} m (d) 100 μm

11. Resolving power of scanning electron microscope is **[DPMT 2007]**

(a) 5 – 20 nm (b) .01 nm

(c) .1 nm (d) .0001

12. Fluidity of bio-membranes can be shown by **[DUMET 2009]**

(a) Electron microscope

(b) Tissue culture

(c) Phase-contrast microscope

(d) Fluorescence microscope

13. The dry weight of macromolecules like DNA, RNA and proteins can be determined using **[Kerala PMT 2009]**

(a) Fluorescent microscopy

(b) Dark field microscopy

(c) Phase contrast microscopy

(d) Differential interference contrast microscopy

(e) Scanning electron microscopy

14. The smallest size of a cell which can be seen with unaided eye is or differentiation capacity of human eye is **[RPMT 1999]**

(a) 1 micron (b) 10 micron

(c) 100 micron (d) 1000 micron

15. Ultrastructure of cell can be best studied by **[CBSE PMT 1999; MP PMT 2003; PET (Pharmacy) 2013]**

(a) Autoradiography

(b) X–ray diffraction method

(c) Phase contrast microscope

(d) None of these

16. Which one of the following statements is not true **[Kerala PMT 2009]**

(a) Immersion oil increases the refractive index

(b) Fluorescent microscopy uses the normal light to view molecules

(c) Electron microscope has only electromagnetic lenses

(d) Scanning tunneling microscope is useful in scanning computer chips for defects

(e) Density gradient centrifugation can be used in the separation of cellular organelles

17. Electron microscope is based on principle of **[WB JEE 2009]**
(a) Electromagnetic theory
(b) Resolution of glass lenses
(c) Magnification of glass lenses
(d) Refraction of light

18. The resolving power of a compound microscope will increase with **[WB JEE 2009]**
(a) Decrease in wavelength of light and increase in numerical aperture
(b) Increase in wavelength of light and decrease in numerical aperture
(c) Increase in both wavelength of light and numerical aperture
(d) Decrease in both wavelength of light and numerical aperture

19. A major breakthrough in the study of cells came with the development of electron microscope. This is because **[CBSE PMT 2006]**
(a) 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 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

20. With the increase in diameter of the rotor, the effective RCF (relative centrifugal force) at a fixed RPM (revolutions per minute) will **[DUMET 2010]**
(a) Remain unaffected
(b) Increase
(c) Decrease
(d) Be lower at the bottom of centrifuge tube

21. Electrons used in electron microscope are of the wavelength **[WB JEE 2011]**
(a) 0.05Å (b) 0.15Å
(c) 0.25Å (d) 0.30Å

22. Stain used by Feulgen to stain DNA is **[MP PMT 2007]**
(a) Janus green (b) Basic fuschin
(c) Crystal violet (d) Methylene blue

23. Agarose extracted from sea weeds finds use in **[CBSE PMT (Pre.) 2011]**
(a) Gel electrophoresis (b) Spectrophotometry
(c) Tissue culture (d) PCR

24. The distribution of two or more specific molecules within a cell can be studied by using **[Kerala PMT 2006]**
(a) Dark field microscope
(b) Flourescent microscope
(c) Phase contrast microscope
(d) Interference contrast microscope
(e) Bright field microscope

25. Microtome was developed by **[MHCET 2001]**
(a) Talbot (b) Brogy
(c) Merten (d) W. His

26. Which of the following techniques is used to extract proteins from the cell fractionation **[AFMC 2012]**
(a) Ultracentrifugation (b) Chromatography
(c) Autoradiography (d) Electrophoresis

27. Detailed structure of the membrane was studied after the advent of electron microscope during **[NCERT; AMU (Med.) 2012]**
(a) 1930's (b) 1950's
(c) 1970's (d) 1990's

28. Electron microscope is made up of **[MP PMT 2004]**
(a) Objective and ocular lenses
(b) Polarizer and analyzer filters
(c) Electromagnetic lenses
(d) Fluorochromes

29. In confocal microscope, the specimen is illuminated by **[Odisha JEE 2004]**
(a) UV ray (b) Laser beam
(c) Electron flow (d) None of these

30. One micrometer is a unit equivalent to **[DPMT 2004; WB JEE 2012]**
(a) 10^{-3} *m* (b) 10^{-6} *m*
(c) 10^{-9} *m* (d) 10^{-12} *m*

31. Which lenses in electron microscope are used to control and focus a **[DPMT 2004]**
(a) Convex lens (b) Concave lens
(c) Electric lens (d) Magnetic lens

32. Which of the following is used for observing spindle fibres **[DPMT 2004]**

Or

The microscope usually used for seeing living cells or tissues **[AIIMS 2012]**
(a) Dark field microscope
(b) Phase contrast microscope
(c) Polarisation microscope
(d) Scanning transmission electron microscope

33. Following technique uses radioactive precursors for observing metabolic activities of macromolecules, is **[DPMT 2004]**

Or

Which of the following technique, other than microscopy is used for study of cell **[BHU 2004]**
(a) Chromatography
(b) Density gradient centrifugation or cell fractionation
(c) Autoradiography
(d) Electron microscope

34. Numerical aperture of microscope lens is expressed by **[WB JEE 2012]**
(a) Angular aperture only
(b) Refractive index only
(c) Both angular aperture and refractive index
(d) Wave length of the light used

35. Which of the following is used for staining of lipids **[Odisha JEE 2012]**
(a) Rhodamine (b) Iodine
(c) Oil red *O* (d) Ethidium bromide

36. Pure fractions of cellular components can be isolated by **[Kerala CET 2005]**
(a) Chromatography
(b) Scanning electron microscopy
(c) *X*-ray diffraction
(d) Differential centrifugation
(e) Autoradiography

37. Scientists were able to pinpoint the location of colour processing centres in the visual cortex of the brain by means of **[Kerala PMT 2005]**
(a) PET (b) NMR
(c) CT (d) *X*- ray
(e) Ultra sound imaging

Cell Introduction and Cell Theory

1. Who proposed the "Cell theory" **MP PMT 1995, 96, 98, 2001, 05; CPMT 1998; AMU (Med.) 2001; BHU 2002; Kerala PMT 2002, 03; HP PMT 2005; AIIMS 2011; PET (Pharmacy) 2013]**
(a) Schleiden (botanist) and Schwann (zoologist)
(b) Watson and Crick
(c) Mendel and Morgan
(d) Robert Hooke

2. Which of the following is the exception of cell theory **[CMC Vellore 1993; BVP 2004; Kerala PMT 2004; Odisha JEE 2011; MP PMT 2011]**
(a) Bacteria (b) Fungi
(c) Lichen (d) Virus

3. Difference between the prokaryotic and eukaryotic cells in having **[AFMC 2002]**
(a) Cell wall (b) Nuclear membrane
(c) Ribosome (d) None of these

4. Intracellular compartments are not found in cells of **[MP PMT 1997]**
(a) Lower plants (b) Prokaryotes
(c) Higher plants (d) Eukaryotes

5. How many types of cells are known **[MP PMT 2000]**
(a) One (b) Two
(c) Three (d) Four

6. The division of the plant kingdom into Prokaryota and Eukaryota is based on the characters of **[MP PMT 1995, 98]**
(a) Nucleus only (b) Chromosomes only
(c) Cell organelles only (d) All the above

7. T. Schwann and M. Schleiden were **[CPMT 2001; BHU 2001]**
(a) Dutch biologists (b) English biologists
(c) Austrian biologists (d) German biologists

8. Who proposed the theory that "cells arise only from the pre-existing cells" **[AMU (Med.) 1993, 2010; MP PMT 1997]**
(a) Mohl (b) Virchow
(c) Haeckel (d) Brown

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

10. Which of the following is seen only in prokaryotic cells **[Kerala PMT 2012]**
(a) Dictyosome (b) Ribosome
(c) Mesosome (d) Endoplasmic reticulum
(e) DNA

11. Which of the following forms more than 1/2 of cell **[AFMC 2001]**
(a) Water (b) Mineral
(c) Protein (d) Carbohydrate

12. The smallest living cells with cell wall are **[MP PMT 1994]**
Or
Which of the following is a prokaryote **[MP PMT 2007; Odisha JEE 2009]**
(a) Viroids (b) Algae
(c) Bacteria (d) Mycoplasma

13. Which of the following is absent in prokaryotes **[KCET 2005]**
(a) DNA (b) RNA
(c) Plasma membrane (d) Mitochondria

14. Which one of the following pairs is not correctly matched **[MP PMT 1993]**

(a) Cristae	The "Shelves" formed by the folding of the inner membrane of the mitochondrion
(b) Plasmodesmata	The membrane surrounding the vacuole in plants
(c) Grana	Membrane bound discs in chloroplasts that contain chlorophylls and carotenoids
(d) Middle lamella	Layer between adjacent cell walls in plants derived from cell plate

15. The branch which deals with the study of cell structure and function is known as **[BHU 2000; MHCET 2000, 03; Pb. PMT 2004]**
(a) Histology (b) Ecology
(c) Morphology (d) Cytology

16. Schleiden (1838) proposed that cell is the structural and functional unit of life. His idea was a **[CPMT 2004]**
(a) Assumption (b) Generalization
(c) Hypothesis (d) Observation

17. The cell organelles are found in **[MP PMT 1996]**
(a) Bacterial cells (b) Cyanobacterial cells
(c) Prokaryotic cells (d) Eukaryotic cells

18. The size of most of the cells is best expressed in **[CPMT 1998]**
(a) Å (b) Milimeters (*mm*)
(c) Nanometers (*nm*) (d) Micrometers (μm)

19. The word "Prokaryote" means a cell **[JIPMER 1995]**
(a) With many nuclei (b) With one nucleus
(c) With diffused nucleus (d) Without chloroplast

20. Robert Hooke used the term cell in the year **[AFMC 1997; CPMT 2003; BHU 2004]**

(a) 1650 (b) 1665
(c) 1865 (d) 1960

21. Which of the following is not a cell organelle **[Bihar MDAT 1992; RPMT 2002]**

(a) Mitochondria (b) Ribosome
(c) Golgi complex (d) Microsome

22. Which one is the largest unicellular organism **[Kerala PMT 2004]**

(a) *Planaria* (b) *Volvax*
(c) Blue green algae (d) *Yeast*
(e) *Acetabularia*

23. Smallest known cell is **[RPMT 1999]**

(a) *Acetabularia*
(b) *Nostoc*
(c) *Chlamydomonas*
(d) *Pleuropneumonia like organism*

24. The cell theory states that **[MP PMT 1995]**

(a) All cells have nuclei
(b) All cells are totipotent
(c) Cells reproduce by mitosis
(d) Cells are the basic structural units of living beings

25. The main difference between plant and animal cell is **[HP PMT 2005]**

(a) Animal cells lack cell wall
(b) Plant cell has no cell wall
(c) Animal cell has a rigid cell wall
(d) Plant cells lack cell membrane

26. Match the following and choose the correct combination from the options given

	Column I		Column II
A.	Robert Hooke	1.	Mutation theory
B.	Charles Darwin	2.	Swan-necked flask experiment
C.	Hugo de vries	3.	Origin of species
D.	Louis pasteur	4.	Micrographia

[MH CET 2001; Kerala PMT 2004]

(a) A-3, B-4, C-1, D-2 (b) A-2, B-1, C-3, D-4
(c) A-1, B-2, C-3, D-4 (d) A-4, B-3, C-1, D-2
(e) A-4, B-2, C-3, D-1

27. Which of the following is absent in prokaryotes **[CPMT 1994; AIPMT 2015]**

(a) Nuclear membrane (b) Golgi bodies
(c) Endoplasmic reticulum (d) All the above

Cell wall

1. Which one of the following structures between two adjacent cells is an effective transport pathway **[CPMT 1993; CBSE PMT 2009; CBSE PMT (Pre.) 2010]**

Or

Cytoplasm of one cell is connected with other through **[CPMT 1996; AFMC 1999; AIIMS 2003; DUMET 2010; Kerala PMT 2012]**

(a) Plasmalemma (b) Plasmodesmata
(c) Plastoquinones (d) Endoplasmic reticulum

2. Middle lamella is made up of **[NCERT; CPMT 1993; MP PMT 1995, 2011; MHCET 2001; CBSE PMT 2002, 09; AFMC 2003; DUMET 2009; Odisha JEE 2011]**

(a) Cellulose
(b) Suberin
(c) Calcium and magnesium pectate
(d) Lignin

3. The internal layer joining the primary walls of the two adjacent cells is known as **[MP PMT 1994]**

Or

The possibility of being outermost layer of cell is highest for which of the following

(a) Plasmodesmata (b) Middle lamella
(c) Periderm (d) Casparian strip

4. The strength and rigidity of a cell wall is due to the substance known as **[MP PMT 1994, 2006]**

(a) Suberin (b) Cellulose
(c) Lignin (d) Pectin

5. The most abundant substance of middle lamella is **[MP PMT 2013]**

(a) Suberin (b) Cutin
(c) Lignin (d) Pectin

6. A mature plant cell has **[MP PMT 1999, 2000]**

(a) Cell wall and protoplasm
(b) Protoplasm and vacuole
(c) Vacuole and cell wall
(d) Protoplasm, cell wall and vacuole

7. Plant cell wall consists of **[NCERT; CPMT 1995, 98; MP PMT 2013]**

(a) Lignin + hemicelluloses + pectin + lipid
(b) Lipid + protein + hemicelluloses + pectin
(c) Lignin + hemicelluloses + pectin + cellulose
(d) Lignin + hemicelluloses + tubulin + cellulose

8. Identify the polysaccharide with β-glycosidic bonds **[WB JEE 2012]**

(a) Starch (b) Glycogen
(c) Sucrose (d) Cellulose

9. Cell wall is absent in **[BVP 2000; MHCET 2001; MP PMT 2009, 13]**

(a) Gametes (b) *Amoeba*
(c) Mycoplasma (d) All of these

10. The plant cell wall is made up of cellulose. This is believed to be **[CPMT 1993; MP PMT 2002]**

(a) A liquid (b) A protein
(c) A polysaccharide (d) An amino acid

11. A protoplast is a cell **[AIPMT 2015]**

(a) Without nucleus
(b) Undergoing division
(c) Without cell wall
(d) Without plasma membrane

12. What is the structural element of cell wall **[WB JEE 2008]**

(a) Matrix (b) Microtubules
(c) Microfibrils (d) Arabinogalactans

13. In the cell walls of the guard cells, cellulose microfibrils are oriented **[AMU (Med.) 2009]**
(a) Radially (b) Transversely
(c) Tangentially (d) Obliquely

14. The chemical substances found most abundantly in the middle lamella is released into the phragmoplast by **[EAMCET 2009]**
(a) Endoplasmic reticulum (b) Golgi complex
(c) Spindle fragments (d) Interzonal fibres

15. Which is correct for the structure of cell wall of bacteria and fungi **[CPMT 1998; MHCET 2003]**
(a) Both are made up of cellulose
(b) Both have mucopeptide
(c) Both are made up of N-acetylglucosamine
(d) None of these

16. In plants, both cellulose and hemicellulose are major components of which one of the following **[WB JEE 2016]**
(a) Plasma membrane (b) Cell wall
(c) Nuclear membrane (d) Mitochondrial membrane

Plasma Membrane

1. The plasma membrane consists mainly of **[MP PMT 1996, 97, 2001, 12; CBSE PMT 2002; Odisha JEE 2008, 11; CBSE PMT (Pre.) 2010]**
(a) Proteins embedded in a carbohydrate bilayer
(b) Phosholipids embedded in a protein bilayer
(c) Proteins embedded in a phospholipid bilayer
(d) Proteins embedded in a polymer of glucose molecules

2. For cell membrane, name "plasmalemma" was given by **[CPMT 2010]**
(a) Porter (b) Nageli
(c) Cramer (d) Plowe

3. Most abundant Lipid in cell membrane is **[Odisha JEE 2008; WB JEE 2011]**
(a) Phospholipid (b) Starch
(c) Oil (d) Sulpholipid

4. Beet root if kept in cold water anthocyanin does not come out due to plasma membrane **[BHU 2003]**
(a) Differentially permeable
(b) Impermeable to anthocyanins
(c) Permeable to anthocyanins
(d) Dead

5. Which of the following layer is present nearest to plasma membrane in plant cell **[AFMC 2002]**
(a) Secondary wall (b) Middle lamella
(c) Primary wall (d) Tonoplast

6. 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 mono layer to the other (described as flip flop movement) **[CBSE PMT 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

7. Lipid molecule in plasma membrane are arranged in **[CPMT 2002; RPMT 2005]**
(a) Scattered (b) Series
(c) Alternate (d) Head parallel

8. Select of correct statement from the following regarding cell membrane **[CBSE PMT (Pre.) 2012]**

Or

Who proposed "fluid mosaic model" for plasma membrane **[NCERT; RPMT 1999, 2006; BHU 2000, 01; Pb. PMT 2004; Odisha JEE 2004, 11; DPMT 2006; J & K CET 2010; MP PMT 2011]**
(a) Na^+ and K^+ ions move across 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 cell membrane was proposed by Singer and Nicolson

9. Ion carriers are located in **[KCET 2000]**
(a) Nucleus (b) Cell wall
(c) Cellular space (d) Plasma membranes

10. The type of cell junction which facilitates cell to cell communication is **[Kerala PMT 2008; AIPMT 2015]**
(a) Tight junction (b) Adhering junction
(c) Gap junction (d) Desmosomes
(e) Brush borders

11. Desmosomes are concerned with **[CBSE PMT 1995; AIIMS 2010]**
(a) Cell division (b) Cellular excretion
(c) Cytolysis (d) Cell adherence

12. On which surface of cell Donnan equilibrium occur **[GUJCET 2015]**

Or

Desmosome is a modification of **[MP PMT 2004]**
(a) Cell wall (b) Tonoplast
(c) Plasma membrane (d) Nuclear membrane

13. According to the 'Unit membrane model' the thickness of the cell membrane is about **[MP PMT 1994]**
(a) 200 *nm* (b) 7.5 *nm*
(c) 150 *nm* (d) 1.0 *nm*

14. Which of the following does not require carrier molecules during transport through cell membranes **[BHU 1994; WB JEE 2008]**
(a) Simple diffusion
(b) Facilitated diffusion
(c) $Na^+ - K^+$ transport
(d) Active transport of sugars and amino acids

15. Which of the following structures controls the transport of the material into and out of living cells or controls permeability **[BHU 1999; Odisha JEE 2005]**

Or

Which one of the following does not differ in *E. coli* and *Chlamydomonas* **[CBSE PMT (Pre.) 2012]**
(a) Centrosome (b) Cell membrane
(c) Cell wall (d) Ribosome

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

17. Which of the following constituent of biological membrane **[MP PMT 2002, 03; AIEEE Pharmacy 2004]**
(a) Phosphoprotein (b) Protein and Phospholipid
(c) Phospholipids (d) Cellulose

18. Plasma membrane helps in **[J & K CET 2005]**
(a) Transportation of only water in and out of cell
(b) Protein synthesis
(c) Osmoregulation
(d) Nucleic acid synthesis

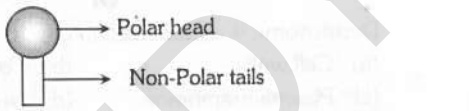
19. The non-membranous structure is **[DPMT 2004]**
(a) Centrioles (b) Ribosomes
(c) Nucleolus (d) All of these

20. Single membrane bound organelles are **[CBSE PMT 1999; DPMT 2004]**
(a) Lysosome (b) Sphaerosome
(c) Glyoxysome (d) All of these

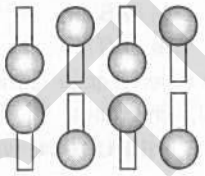
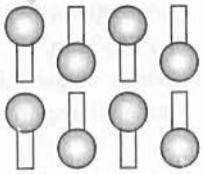
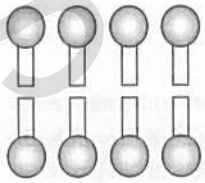
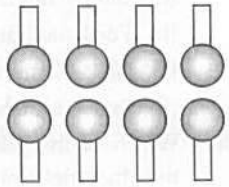
21. Which one of the following is not a constituent of cell membrane **[CBSE PMT 2007]**
(a) Cholesterol (b) Glycolipids
(c) Proline (d) Phospholipids

22. The cell membranes of adjacent cells are fused at this cell junction **[AMU (Med.) 2010, 12]**
(a) Macula adherens (b) Zonula adherens
(c) Zonula occludens (d) Nexus

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



Which of the following figure represents the correct arrangement of lipids in lipids bilayer **[NCERT]**

(a) 
(b) 
(c) 
(d) 

24. Bulk drinking of fluid by cells is termed as **[CBSE PMT 1993; CPMT 2000]**

Or

The process of sucking of fluid from the cell surface is called **[RPMT 1999]**
(a) Phagocytosis (b) Pinocytosis
(c) Cyclosis (d) Osmosis

25. Thickness of plasma membrane is **[MP PMT 2003, 09]**
(a) 10 Å to 30 Å (b) 30 Å to 50 Å
(c) 50 Å to 70 Å (d) 70 Å to 100 Å

26. The process of cell eating is called **[KCET 2000]**
(a) Pinocytosis (b) Phagocytosis
(c) Endocytosis (d) Exocytosis

27. According to 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 **[NCERT; CBSE PMT 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

28. Which is the latest model that is proposed to explain the structure of plasma membrane **[BHU 2001; CBSE PMT 2002; BVP 2003]**
(a) Fluid mosaic model (b) Molecular model
(c) Unit membrane model (d) None of the above

29. According to mosaic model, plasma membrane is made up of
(a) Cellulose and hemicellulose
(b) Phospholipid and integrate protein
(c) Phospholipid, extrinsic and intrinsic protein
(d) Phospholipid and hemicellulose

30. Lomasomes are found in **[BVP 2000]**
(a) Algal cell (b) Fungal cell
(c) Yeast (d) *E. coli*

31. Singer and Nicholson's model of plasma membrane differs from Robertson's model in the
(a) Number of lipid layers
(b) Arrangement of lipid layers
(c) Arrangement of proteins
(d) Absence of protein in Singer and Nicholson's model

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

33. Match the following items in column-I with those in column-II and choose the correct answer **[WB JEE 2016]**

Column-I		Column-II	
P.	Plasma membrane mainly contains	i.	Hemicellulose
		ii.	Calcium pectate
Q.	Middle lamella mainly composed of	iii.	Proteinaceous filaments
		iv.	Proteins embedded in phospholipid bilayer

(a) P-ii, Q-i (b) P-i, Q-ii
(c) P-iv, Q-ii (d) P-iii, Q-iv

Protoplasm and Cytoplasm

1. The name 'protoplasm' was given by **[CPMT 1994; MP PMT 1999, 2000; MHCET 2001; Pb. PMT 2004; J & K CET 2005]**
(a) Purkinje (b) Hooke
(c) A.K. Sharma (d) Schwann

2. Both plants and animals are provided with **[KCET 1998]**
(a) Cell wall (b) Golgi body
(c) Chloroplast (d) Protoplasm

3. Ribonucleoprotein particles of protoplasm are **[RPMT 2006]**
(a) Ribosomes (b) Plastid
(c) Golgi body (d) Cristae

4. The amount of which of the element is greatest in protoplasm **[RPMT 1997, 99]**
(a) Hydrogen (b) Oxygen
(c) Nitrogen (d) Carbon

5. Normal *pH* of Protoplasm is **[RPMT 1999]**
(a) 7.8 (b) 6.8
(c) 5 (d) 6.5

6. Cyclosis is **[KCET 1994; RPMT 1997]**
(a) Circular movement of cytoplasm inside the cell
(b) Up and down movement of protoplasm
(c) To and fro movement of nucleoplasm
(d) None of the above

7. The term 'cytoplasm' and 'nucleoplasm' were given by **[KCET 2007]**
(a) Purkinje (b) Strasburger
(c) Brown (d) Flemming

8. In higher plants, continuity of cytoplasm from one cell to its neighbouring cells is established through **[WB JEE 2012]**
(a) Apoplast (b) Chloroplast
(c) Leucoplast (d) Symplast

9. Protoplasm is a **[Pune CET 1998]**
(a) True solution (b) Suspension
(c) Emulsion (d) Polyphasic colloidal system

10. The substance which makes up about 80% of cytoplasm and has unique structure **[Kerala CET 2002]**
(a) Proteins (b) Fats
(c) Minerals (d) Water

11. The main arena of various types of activities of a cell is **[CBSE PMT (Pre.) 2010]**
Or
Proteins required for functioning of nucleus are formed in **[BHU 2012]**
(a) Nucleus (b) Plasma membrane
(c) Mitochondrian (d) Cytoplasm

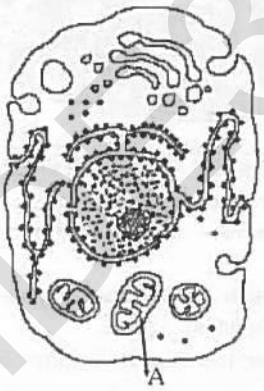
12. Protein synthesis in an animal cell, takes place **[CBSE PMT 1997]**
(a) Only in the cytoplasm
(b) In the cytoplasm as well as in mitochondria
(c) In the nucleolus as well as in the cytoplasm
(d) Only on ribose attached to nucleon

13. Protoplasm was regarded as the "physical basis of life" by **[Odisha JEE 1992; BHU 1992; CPMT 1993; MP PMT 1999; BVP 2000]**
(a) Huxley (1868) (b) Corti (1772)
(c) Hardy (1899) (d) Malphighi (1903)

Mitochondria

1. Who observed the "mitochondria" first **[PET (Pharmacy) 2013]**
(a) Kolliker (b) Robert Brown
(c) Robert Hooke (d) Altmann

2. Select the alternative giving correct identification and function of the organelle 'A' in the diagram



[NEET (Karnataka) 2013]
(a) Mitochondria – produce cellular energy in the form of ATP
(b) Golgi body – provides packaging material
(c) Lysosomes – secrete hydrolytic enzymes
(d) Endoplasmic reticulum – synthesis of lipids

3. Mitochondria perform all of the following functions except **[AFMC 2008]**
(a) Nucleic acid synthesis
(b) β – oxidation of fatty acids
(c) ATP synthesis
(d) Polysaccharide degradation

4. In mitochondria, protons accumulate in the **[CBSE PMT (Mains) 2011]**
(a) Intermembrane space (b) Matrix
(c) Outer membrane (d) Inner membrane

5. Prokaryotic origin of mitochondria was proposed by **[Pune CET 1998]**
(a) Rabinowitch (b) Altmann and Schimper
(c) Salton (d) Morrison

6. Mitochondria are related to **[MP PMT 1999]**
(a) Prokaryotes (b) Plasmids
(c) Plastids (d) Viruses

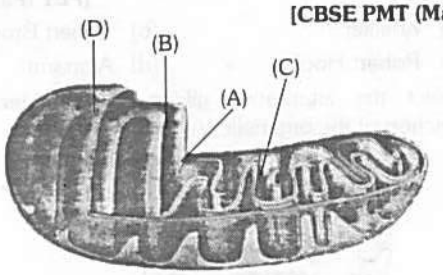
7. F_1 particles / oxysome/ elementary particles are present in **[RPMT 1995; PUNE CET 1998; CPMT 1999; AFMC 1999; JIPMER 2001; MP PMT 2002; MHCET 2004; Odisha JEE 2004; AIEEE Pharmacy 2004]**
(a) Endoplasmic reticulum (b) Chloroplast
(c) Mitochondria (d) Golgi complex

8. The number of mitochondria increases in cells of **[MP PMT 1997]**
(a) Dormant seeds (b) Germinating seeds
(c) Dry seeds (d) Dead seeds

9. In prokaryotes, the mitochondria are absent. Even then Kreb's cycle takes place. What is the site of Kreb's cycle in bacteria **[Bihar MDAT 1995]**

(a) Ribosomes (b) Nucleoid
(c) Cytoplasm (d) Mesosomes

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



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

11. What is mitoplast **[WB JEE 2010]**

(a) Membraneless mitochondria
(b) Another name of mitochondria
(c) Mitochondria without outer membrane
(d) Mitochondria without inner membrane

12. Rackers particles are found in **[Manipal 2005]**

Or

Fernandez Morgan particles are seen in **[Odisha JEE 2012]**

(a) Chromosome (b) Mitochondria
(c) Nucleus (d) Golgibody

13. Folding of inner membrane of mitochondria are called **[MHCET 2004; MP PMT 2004, 05; Kerala PMT 2010]**

(a) Cristae (b) Grana
(c) Calcium oxalate crystals (d) Sacs

14. Organelles which are regarded as 'Power house' of the cell and in which the oxidative reactions of the respiratory process takes place are **[KCET 1994, 2004; Bihar MDAT 1995; CPMT 2001, 02; MP PMT 2003, 04; RPMT 2005; AFMC 2009]**

Or

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

(a) Chloroplast (b) Ribosomes
(c) Endoplasmic reticulum (d) Mitochondria

15. Who first introduced the term 'mitochondrion' **[KCET 1999; Pb. PMT 2004]**

(a) Kolliker (b) Robert Brown
(c) Benda (d) Altman

16. Which of the following cell organelle is considered to be rich in catabolic enzymes **[Pb. PMT 1999; MP PMT 2002, 13; CPMT 2002; DPMT 2003]**

Or

Respiratory and oxidative enzymes are present in **[AFMC 1995; CPMT 2001]**

Or

Highest number of enzyme is found in **[MP PMT 2007]**

(a) Endoplasmic reticulum (b) Lysosome
(c) Golgi body (d) Mitochondria

17. In which of the following parts of mitochondria, succinic dehydrogenase enzyme is located **[MP PMT 2012]**

Or

In mitochondria, enzyme cytochrome oxidase is present in **[MP PMT 2009]**

(a) Outer membrane (b) Inner membrane
(c) Perimitochondrial space (d) Matrix

18. The cristae of mitochondria possess **[MHCET 2002]**

(a) Oxysomes (b) Peroxisomes
(c) Nucleosomes (d) Quantasomes

19. Mitochondria are non-existent in **[MP PMT 1994, 2011]**

(a) Red algae (b) Some bacteria
(c) Green algae (d) Brown algae

20. Mitochondria supply most of the necessary biological energy by **[MP PMT 1994]**

(a) Breaking down of sugar
(b) Oxidizing substrates of TCA cycle
(c) Reducing NADP
(d) Breaking down of protein

21. The size of mitochondria in plant cell is **[AMU (Med.) 2010]**

(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

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

(a) The inner membrane is highly convolated forming a series of infoldings
(b) The outer membrane resembles as 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

23. Which one of the following human cells does not contain mitochondria **[WB JEE 2011]**

(a) Nerve cell (b) Red blood cell
(c) Liver cell (d) White blood cell

24. Autonomic genome system is present in **[MP PMT 2000]**

(a) Ribosomes and chloroplasts
(b) Mitochondria and ribosomes
(c) Mitochondria and chloroplasts
(d) Golgi bodies and mitochondria

25. The presence of DNA in mitochondria and chloroplast supports the hypothesis that **[J & K CET 2002]**
(a) Mitochondria and chloroplast both originated as independent free living organisms
(b) Glycolysis occurs in mitochondria and chloroplast both
(c) ATP is produced in mitochondria and chloroplast both
(d) Mitochondria and chloroplast undergo meiosis and mitosis independent of nucleus

26. Centre of phosphorylation **[AFMC 2000]**
(a) Peroxisome (b) Oxysome
(c) Ribosome (d) Mitochondria

27. In which part of mitochondria, ATP is generated **[HPMT 1999; BHU 2003; CPMT 2010]**
(a) Matrix (b) Cristae
(c) Outer membrane (d) F_1 particles (oxysomes)

28. The reaction of ATP formation is
(a) Exergonic (b) Endergonic
(c) Spontaneous (d) Reversible

29. Identify the membrane across which the proton (H^+) gradient facilitates ATP synthesis in a typical eukaryotic cell **[WB JEE 2012]**
(a) Plasma membrane
(b) Mitochondrial inner membrane
(c) Mitochondrial membrane
(d) Nuclear membrane

30. Mitochondria are semi autonomous as they possess **[WB JEE 2010]**
(a) DNA (b) DNA + RNA
(c) DNA + RNA + ribosomes (d) Protein

31. Which of the following is correct pair **[CBSE PMT 1993]**
(a) DNA synthesis — Ribosomes
(b) Protein synthesis — Smooth E.R.
(c) Aerobic respiration — Cristae
(d) Suicidal sacs — Dictyosomes

32. Mitochondria are the site for **[MP PMT 1996]**
(a) Photophosphorylation (b) Oxidative phosphorylation
(c) Transpiration (d) Carboxylation

Plastids

1. Cell organelles found only in plants **[MP PMT 2001]**
(a) Golgi complex (b) Mitochondria
(c) Plastids (d) Ribosomes

2. Green pigment (Chlorophyll) present in plants is **[AFMC 2002; MP PMT 2005]**
(a) Chromoplast (b) Chloroplast
(c) Ribosome (d) Lysosome

3. The bright colours of ripe fruits are due to **[AIEEE Pharmacy 2003]**

Or

Which of the following type of plastids does not contain stored food material **[NEET (Karnataka) 2013]**
(a) Leucoplasts (b) Chloroplasts
(c) Amyloplasts (d) Chromoplasts

4. Plant cell differ from animal cell because of **[MP PMT 2003]**
(a) The presence of cell wall and absence of chlorophyll in plant cell
(b) The presence of cell wall and chlorophyll in plant cell
(c) The absence of cell wall and presence of chloroplast in animal cell
(d) The absence of cell wall and presence of chlorophyll in plant cell

5. In which plastids are not found **[MP PMT 2000]**
(a) Blue green algae (b) Bacteria
(c) Fungi (d) All of the above

6. Which of the following organelles is bounded by two unit membranes **[Pune CET 1998]**
(a) Golgi complex (b) Peroxisome
(c) Chloroplast (d) Lysosome

7. What is common between chloroplasts, chromoplasts and leucoplasts **[AIIMS 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 process

8. Which one of the following cellular parts is correctly described **[MP PMT 1997; Odisha JEE 2004; CBSE PMT (Mains) 2012; AIPMT (Cancelled) 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 (80s) while those in the cytoplasm are smaller (70s)
(d) Lysosomes-optimally active at a *pH* of about 8.5

9. Thylakoids are constituents of **[MP PMT 1997; WB JEE 2010]**
(a) Chloroplasts (b) Mitochondria
(c) ER (d) Ribosomes

10. In higher plants, the shape of the chloroplast is **[DUMET 2009; MH CET 2015]**
(a) Discoid (Lens) (b) Cup-shaped
(c) Girdle-shaped (d) Reticulate

11. From the following, select the statement that is true **[J & K CET 2012]**
(a) All cells have a cell wall
(b) Animal cells contain microtubules but plant cells do not contain microtubules
(c) The Golgi apparatus is found only in animal cells
(d) Chloroplasts are found in plant cells but not in prokaryotic or animal cells

12. The chloroplasts of algae usually lack **[MP PMT 1994]**
(a) Grana (b) Pigments
(c) Quantasomes (d) Lamellae

13. Aleuroplasts in a cell store **[AMU (Med.) 2010]**
(a) Starch (b) Oil
(c) Protein (d) Nutrients

14. Plant cells differ from animal cells in having **[MP PMT 1995, 98]**
(a) Centrosome (b) Golgi body
(c) Vacuole (d) Plastid

15. Select the wrong statement from the following **[CBSE PMT 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

16. In chloroplasts, chlorophyll is present in the **[CBSE PMT 2004, 05]**
(a) Thylakoids (b) Stroma
(c) Outer membrane (d) Inner membrane

17. The term chromatophore was coined by **[AIIMS 1998]**
(a) Schmitz (b) Comparethi
(c) W. Pfeffer (d) Singer and Nicolsan

18. Quantasomes are found in **[RPMT 2005; HPMT 2005; MP PMT 2009, 11]**
(a) Mitochondria (b) Chloroplast
(c) Lysosome (d) Endoplasmic retiuculum

19. The main difference between chlorophyll '*a*' and '*b*' is
(a) Chlorophyll '*a*' is linear chain compound and '*b*' is branched chain
(b) Chlrophyll '*a*' has no Mg^+ ion in centre of molecule
(c) In chlorophyll '*a*' there is CH_3 group whereas in '*b*' it is – *CHO* group
(d) All of the above

20. In land plants the guard cells differ from other epidermal cells in having **[CBSE PMT (Pre.) 2011]**
(a) Chloroplasts (b) Cytoskeleton
(c) Mitochondria (d) Endoplasmic reticulum

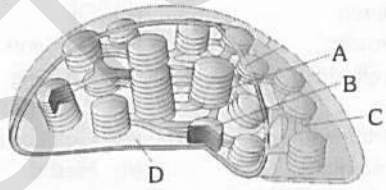
21. Match Column – I with Column – II and select the correct option

Column – I (Type of Chloroplast)		Column – II (Algae)	
A.	Cup shaped	1.	*Ulothrix*
B.	Girdle shaped	2.	*Oedogonium*
C.	Stellate	3.	*Chlamydomonas*
D.	Reticulate	4.	*Zygnema*

[Kerala PMT 2007]
(a) A – 2, B – 4, C – 3, D – 1 (b) A – 3, B – 1, C – 4, D – 2
(c) A – 3, B – 4, C – 2, D – 1 (d) A – 4, B – 3, C – 1, D – 2
(e) A – 3, B – 4, C – 1, D – 2

22. Water soluble yellowish pigment present in petals of Dahlia is **[MP PMT 2004]**
(a) Carotene (b) Xanthophyll
(c) Anthoxanthin (d) Anthocyanin

23. 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 **[NCERT]**
(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

24. Stroma is the ground material of which of the following **[MP PMT 2004]**
(a) Lysosomes (b) Ribosomes
(c) Chloroplasts (d) Mitochondria

25. The amyloplasts look like **[AFMC 1997]**
(a) Proplastids (b) Elioplast
(c) Aleuroplast (d) Chloroplast

26. Which of these is mis-match **[DPMT 2007; Kerala PMT 2007, 09, 10; AFMC 2008; CPMT 2010]**
(a) Amyloplasts - Store protein granules
(b) Elaioplasts - Store oils or fats
(c) Chloroplasts - Contain chlorophyll pigments
(d) Chromoplasts - Contain coloured pigments other than chlorophyll
(e) Leucoplasts - Contain colourless pigment

27. Red colour of tomato is due to **[Odisha JEE 2004; MP PMT 2011]**
(a) β-carotene (b) Anthocyanin
(c) Lycopene (d) Erythrocyanin

28. When green tomatoes fruits turn to red, then **[AFMC 2003]**
(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

29. Extranuclear DNA in the cytoplasm is found inside **[CPMT 1994; AFMC 2012]**
(a) Chloroplast/Mitochondria (b) Ribosome
(c) Endoplasmic reticulum (d) Golgi apparatus

30. All plastids have essentially same structure because **[CBSE PMT 1994]**
(a) They have to perform same function
(b) They are localized in aerial parts of 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

31. Chromoplast may be of **[CPMT 1994]**
(a) Orange colour (b) Red colour
(c) Yellow colour (d) All the above

32. The thylakoid in chloroplast are arranged as **[BHU 2003]**
(a) Interconnected disc (b) Interconnected sacs
(c) Stacked discs (d) None of these

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

Endoplasmic reticulum and Golgi body

1. Which of the following is a part of endomembrane system of eukaryotic cell **[J & K CET 2008]**
(a) Peroxisomes (b) Chloroplasts
(c) Mitochondria (d) Golgi complexes

2. Which type of membrane is most abundant within a cell **[WB JEE 2008]**
(a) ER membrane (b) Nuclear membrane
(c) Golgi membrane (d) Plasma membrane

3. The transfer vesicle from RER fuse with which region of golgi complex **[CPMT 2000]**
(a) Cis (b) Medial
(c) Trans (d) Protein arms

4. Nuclear envelope is a derivative of **[AIPMT (Cancelled) 2015]**
(a) Membrane of Golgi complex
(b) Microtubules
(c) Rough endoplasmic reticulum
(d) Smooth endoplasmic reticulum

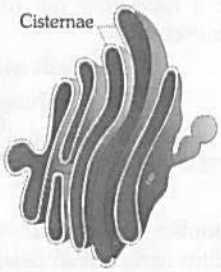
5. Endoplasmic reticulum is more developed in **[MP PMT 1999]**
(a) Green cells (b) Young cells
(c) Mature cells (d) Bacteriophage

6. An interconnecting membranous network of the cell composed of vesicles, flattened sacs and tubules is **[KCET 2012]**

Or

Nuclear membrane is formed around the groups of daughter chromosomes during the telophase by **[WB JEE 2016]**
(a) Nucleus (b) Mitochondrion
(c) Endoplasmic reticulum (d) Lysosome

7. See the figure and identify it **[NCERT]**



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

8. Important site for formation of glycoproteins and glycolipids is **[NCERT; CBSE PMT (Pre.) 2011]**
(a) Lysosome (b) Vacuole
(c) Golgi apparatus (d) Plastid

9. The most important function of endoplasmic reticulum is **[DPMT 1993; HPMT 2005]**
(a) Protein synthesis (b) Nourishing the nucleus
(c) Secretion of materials (d) To give shape to the cell

10. In rapidly dividing cells, endoplasmic reticulum is **[MP PMT 1994]**
(a) Highly developed (b) Poorly developed
(c) Absent (d) Non-functional

11. Main function of dictyosomes is **[CPMT 2005]**
(a) Respiration (b) Storage
(c) Secretion (d) Breakdown of fats

12. In endoplasmic reticulum the following process take place **[MP PMT 2001]**
(a) Lipid synthesis
(b) Channeling of biosynthetic processes
(c) Steroid synthesis
(d) All of the above

13. Mechanical support, enzyme circulation, protein synthesis and detoxification of drugs are function of **[AIIMS 1999; CBSE PMT 2000, 05; AFMC 2006; BHU 2008]**

Or

Which of the following is related to glycosylation of protein **[CBSE PMT 2000]**
(a) *ER* (b) Ribosomes
(c) Dictyosomes (d) Chloroplast

14. The endoplasmic reticulum often bears **[MP PMT 1994; J & K CET 2005]**
(a) Lysosomes (b) Centrioles
(c) Peroxisomes (d) Ribosomes

15. When the region of endoplasmic reticulum are studded by ribosome on their outer surface of the cisternae, it is called **[Pb. PMT 1999; AIIMS 2000]**
(a) Sarcoplasmic reticulum
(b) Smooth endoplasmic reticulum
(c) Granular endoplasmic reticulum
(d) None of the above

16. The cisternae that make up the Golgi complex are **[MP PMT 2013]**
(a) Rough (b) Polarized
(c) Non-polarized (d) Reticulate

17. The endoskeleton of cell is made up of **[AIEEE Pharmacy 2003; DPMT 2003; BVP 2004; PET (Pharmacy) 2013]**
(a) Cell wall (b) Endoplasmic reticulum
(c) Cytoplasm (d) Mitochondria

18. "Endoplasmic reticulum" was discovered by **[MP PMT 2000]**
(a) Porter (b) Altmann
(c) Golgi (d) Benda

19. RER is mainly concerned with **[RPMT 1999]**
(a) Proteolysis (b) Fatty acids synthesis
(c) Peptide bond formation (d) Cholesterol synthesis

20. Which organelle is present in higher number in secretary cells **[MP PMT 2007]**

Or

One of the following serves as a temporary storage place for proteins and other compounds synthesized by endoplasmic reticulum **[AFMC 1993]**
(a) Dictyosome (b) ER
(c) Lysosome (d) Vacuole

21. Endoplasmic reticulum is in continuation with **[BHU 2005; CPMT 2009]**
(a) Golgibody (b) Nuclear wall
(c) Mitochondria (d) Cell wall

22. Golgi body originated from **[CPMT 2002; AFMC 2003; RPMT 2005]**
(a) Lysosome (b) Endoplasmic reticulum
(c) Mitochondria (d) Cell membrane

23. Which is not function of golgibody **[RPMT 1999]**
(a) Secretion
(b) Formation of plasmamembrane
(c) Fat synthesis
(d) Cell wall formation

24. Which of the following is the site of lipid synthesis **[NCERT; Kerala CET 2002; RPMT 2006; AMU (Med.) 2009; NEET 2013; AIIMS 2013; AIPMT (Cancelled) 2015]**
(a) Rough ER (b) Smooth ER
(c) Golgi bodies (d) Ribosome

25. In plant cells the number of golgi bodies increases during **[MP PMT 1997]**

(a) Cell division (b) Food synthesis
(c) Translocation (d) Respiration

26. The golgi apparatus contains **[AIIMS 1993]**

(a) DNA
(b) RNA
(c) Phospholipids, proteins, enzymes and vitamin C
(d) Protein–lipid–protein.

27. Identify the components labelled A, B, C and D in the diagram below from the list (i) to (viii) given along with **[NCERT]**

Components:

(i) Cristae of mitochondria
(ii) 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 **[CBSE PMT (Mains) 2010; NEET 2013]**

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

28. Golgi bodies are absent in **[MP PMT 1999]**

(a) Plants (b) Bacteria
(c) Animals (d) Eukaryotic cells

29. The Golgi complex plays a major role **[CPMT 1996; NEET 2013]**

(a) In post translational modification of proteins and glycosidation of lipids
(b) In trapping the light and transforming it into chemical energy
(c) In digesting proteins and carbohydrates
(d) As energy transferring organelles

30. Secretory and membrane proteins are processed in **[CPMT 2000; MP PMT 2003]**

(a) Peroxisomes (b) Glyoxysomes
(c) Golgi complex (d) Sphaerosomes

Lysosome and Ribosomes

1. "Lysosomes" were discovered by **[Kashmir MEE 1995; CPMT 1996; MP PMT 2003; Odisha JEE 2008]**

(a) Haekel (b) De Duve
(c) De Vries (d) Purkinje

2. Which of the following statements is incorrect with reference to lysosomes **[JIPMER 2002]**

(a) They are 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, nuclei acids, lipids and polysaccharides

3. The element responsible for the ring structure of chlorophyll and maintenance of ribosome structure is **[KCET 2015]**

(a) Ca^{++} (b) Mg^2
(c) S (d) K^+

4. The two sub-units of ribosome remain united at a critical ion level of **[RPMT 2001; CBSE PMT 2008]**

(a) Magnesium (b) Calcium
(c) Copper (d) Manganese

5. What would happen if lysosomes get ruptured inside the cells in which they are present **[MP PMT 1997]**

(a) Cells will swell (b) Cells will shrink
(c) Cells will die (d) Nothing would happen

6. Three of the following statements regarding cell organelles are correct while one is wrong. Which one is wrong **[AIIMS 2005]**

(a) Lysosomes are double membraned 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

7. Match List I and List II and select the correct answer using the code given below the list :

List I		List II	
a	Lysosome	1	Bacteria without cell walls
b	Mycoplasma	2	A virus that infects bacterial cells
c	Thylakoid	3	Flattened sacs in a chloroplast
d	Bacteriophage	4	A vesicle in which hydrolytic enzymes are stored

Code **[MP PMT 1993]**

(a) a b c d
3 1 2 4
(b) a b c d
4 1 3 2
(c) a b c d
2 3 4 1
(d) a b c d
1 4 2 3

8. Ribosome may also be called **[RPMT 2005]**
(a) Microsome (b) Dictyosome
(c) Ribonucleoprotein (d) Oxysomes

9. Lysosomes are so called because these contain **[MP PMT 1994]**
(a) Carboxylating enzymes (b) Respiratory enzymes
(c) Oxidizing enzymes (d) Digestive enzymes

10. The organelles whose major function is storage of hydrolytic enzymes are **[CPMT 1993, 98; MP PMT 1993, 2003, 09; CBSE PMT 1996; BVP 2000; HPMT 2005; RPMT 2005; NEET (Phase-II) 2016]**

Or

Acid hydrolase is found in **[MP PMT 2007; AFMC 2010]**
(a) Centrioles (b) Chromoplasts
(c) Lysosomes (d) Chloroplasts

11. Which of the following subunit of ribosome is composed of 23S rRNA and a 5S rRNA +32 different proteins **[Kerala PMT 2006]**

Or

The largest subunit of prokaryotic ribosomes is **[J & K CET 2008]**
(a) 50 *S* (b) 70 *S*
(c) 30 *S* (d) 60 *S*
(e) 40 *S*

12. The functional unit in the synthesis of protein is **[MP PMT 1994; CBSE PMT 1999]**
(a) Peroxisome (b) Dictyosome
(c) Lysosome (d) Polysome

13. Which one of the following structures is an organelle within an organelle **[CBSE PMT (Mains) 2012]**

Or

Which of the following cell organelle lacks DNA and bounding membrane **[AFMC 2002; AIPMT 2015; AIPMT (Cancelled) 2015]**
(a) Ribosome (b) Peroxisome
(c) ER (d) Mesosome

14. The cell organelle showing extensive polymorphism is **[MHCET 2004; VITEEE 2008]**
(a) Dictyosomes (b) Chloroplasts
(c) Lysosomes (d) Ribosomes

15. Lysosomes are known as *suicidal bags* because of **[BHU 1999, 2012; RPMT 1999, 2006; CBSE PMT 2000; MP PMT 2003; HP PMT 2005; J & K CET 2010; PET (Pharmacy) 2013]**

Or

Which one of the following is stored in lysosome **[WB JEE 2016]**
(a) Catalytic enzymes (b) Hydrolytic enzymes
(c) Parasitic on nucleus (d) Proteolytic enzymes

16. Ribosomes that occur exclusively in mitochondria is **[DPMT 2004]**
(a) 70S (b) 55S
(c) 30S (d) 50S

17. The "marker" enzyme of lysosome is **[DPMT 2007]**
(a) Lysozyme (muramidase) (b) Acid protease
(c) Acid phosphatase (d) Beta–galactosidase

18. Which of the following is present both in prokaryotic and eukaryotic cells **[AFMC 2012; WB JEE 2016]**
(a) Mitochondria (b) Endoplasmic reticulum
(c) Ribosomes (d) Nucleus

19. Peptide synthesis inside a cell takes place in **[Odisha JEE 2009; CBSE PMT (Pre.) 2011]**
(a) Ribosomes (b) Chloroplast
(c) Mitochondria (d) Chromoplast

20. Which of the following cell organelles is having single layered unit membrane **[MP PMT 1995, 98; RPMT 1995; CBSE PMT 2001; CPMT 2005; J & K CET 2005; NEET (Phase-I) 2016]**

Or

In active leaf cells, the double membrane is absent in **[MP PMT 2013]**
(a) Centrosome (b) Lysosome
(c) Mesosome (d) Nucleus

21. Who discovered "ribosomes" in animal cells **[NCERT; BHU 2001]**
(a) Watson (b) Talvim
(c) Cowdry (d) Palade

22. Ribosomes, similar to those of bacteria, are found in **[CBSE PMT 2001]**
(a) Plant nuclei
(b) Pancreatic mitochondria
(c) Liver endoplasmic reticulum
(d) Cardiac muscle cytoplasm

23. Which of the following statements is wrong for ribosomes **[RPMT 1999]**
(a) Formed by two-sub units
(b) Formed by ribo-protein
(c) Formed in chain
(d) Both sub-units are bounded by a membrane

24. Ribosomes of bacteria, mitochondria, prokaryotes (*Nostoc*) and chloroplast are of **[MP PMT 1994, 99; MHCET 2001; J & K CET 2002; Kerala PMT 2004; Odisha JEE 2010; KCET 2011]**
(a) 50 S type (b) 80 S type
(c) 70 S type (d) 30 S type

25. All are membrane bound cell organelles except **[MP PMT 1997; RPMT 1999; DPMT 2003; BVP 2004; WB JEE 2010]**

Or

Which of the following cell organelles lacks a unit membrane **[MP PMT 1995, 98; RPMT 2002; J & K CET 2005; Kerala PMT 2010]**
(a) Mitochondria (b) Lysosomes
(c) Sphaerosomes (d) Ribosomes

26. The 80S ribosomes are present in **[MP PMT 1996; CPMT 1998]**
(a) Eucaryotic cells (b) Procaryotic cells
(c) Bacterial cells (d) Cyanobacterial cells

27. Lysosomes have acidic environment inside their vesicles due to **[BHU 2012]**
(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

28. Polyribosomes are aggregation of **[CBSE PMT 2008]**
(a) Ribosomes and rRNA
(b) Only rRNA
(c) Peroxisomes
(d) Several ribosomes held together by a stearing of mRNA

29. The site of protein synthesis in plants is the **[CPMT 1994; MP PMT 1995, 2003; MDAT Bihar 1995; KCET 1999; CBSE PMT 1999; BVP 2001; BHU 2004; J & K CET 2005, 12; RPMT 2006]**

Or

Which of the following organelle is called as "protein factory of the cell"
(a) Chloroplast (b) Ribosomes
(c) Pyrenoids (d) Mitochondria

30. The cell organelle associated with intercellular digestion of macromolecules is **[MP PMT 1999, 2002; Kerala PMT 2009]**

Or

Which is concerned with autolysis **[BVP 2004]**

Or

One of the cell organelle is said to function as "trigger of cell division"
(a) Lysosome (b) Peroxisome
(c) Polysome (d) Dictyosome
(e) Glyoxysome

31. Most of the hydrolytic enzymes of lysosome function at **[Odisha JEE 2012]**
(a) Acidic pH (b) Alkaline pH
(c) Neutral pH (d) Both (b) and (c)

32. Ribosomes are found in **[MP PMT 2005]**
(a) Cytoplasm (b) Nucleus
(c) Cell wall (d) Golgibody

33. Heterophagosome is **[Odisha JEE 2012]**
(a) Formed by fusion of food containing phagosome with primary lysosome
(b) A newly pinched out vesicle from Golgi apparatus which fuses with endosome to become fully functional
(c) Formed by fusion of primary lysosome with degenerating intracellular organelles
(d) A lysosome in which only indigestible food material is left

34. Which of the following is responsible for the origin of lysosome **[MP PMT 2009]**
(a) Chloroplast (b) Mitochondria
(c) Golgi body (d) Ribosome

35. Ribosomes are made up of **[MP PMT 1995, 98, 2006; BVP 2002; CPMT 2004]**
(a) DNA and protein (b) DNA alone
(c) RNA and protein (d) RNA and DNA

36. 70S type of ribosome shows two units whose sedimentation constants are **[Odisha PMT 2002]**

Or

Sub unit in prokaryotic ribosome is **[DPMT 2007]**
(a) 40 S and 30 S
(b) 50 S and 20 S
(c) 50 S and 30 S
(d) 60 S and 20 S

37. Ribosome mainly has **[DPMT 2004]**
(a) DNA (b) RNA
(c) Carbohydrate (d) None of these

38. Eukaryotic 80 S ribosome breaks into **[MP PMT 1999, 2000, 03]**
(a) 40 S and 40 S (b) 60 S and 40 S
(c) 60 S and 50 S (d) 50 S and 30 S

39. Which of the following pairs is correct **[CBSE PMT 1993]**
(a) Svedberg unit — Biomembranes
(b) Polyribosomes — RNA
(c) Dictyosomes — Suicidal sacs
(d) Cisternae — Mitochondria

40. What is true about ribosomes **[CBSE PMT (Pre.) 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

Sphaerosomes, Peroxisomes, Glyoxysomes and Vacuoles

1. The colour of rose petals is due to water soluble pigments present in the **[MP PMT 1994]**
(a) Cytoplasm (b) Nucleus
(c) Intercellular spaces (d) Vacuoles

2. Match column I with column II and select the correct option

Column I		Column II	
A.	Sap vacuole	1.	Contain digestive enzyme
B.	Contractile vacuole	2.	Store metabolic gases
C.	Food vacuole	3.	Osmoregulation
D.	Air vacuole	4.	Store lipids
E.	Sphaerosomes	5.	Store and concentrate mineral salts & nutrients

[RPMT 1997; Kerala PMT 2006]
(a) A – 5, B – 3, C – 1, D – 2, E – 4
(b) A – 2, B – 3, C – 4, D – 5, E – 1
(c) A – 5, B – 2, C – 3, D – 1, E – 4
(d) A – 5, B – 3, C – 2, D – 4, E – 1
(e) A – 4, B – 1, C – 3, D – 5, E – 2

3. Read the following statements and identify the correct options given

A. Sap vacuoles-contain digestive enzymes with the help of which nutrients are digested options given

B. Contractile vacuoles – take part in osmoregulation and excretion

C. Food vacuoles – store and concentrate mineral salts as well as nutrients

D. Air vacuoles – store metabolic gases and help in buoyancy of cells **[Kerala PMT 2008]**

(a) A and B are correct (b) A and C are correct
(c) A and D are correct (d) B and D are correct
(e) B and C are correct

4. Which is not true about sphaerosomes **[Odisha JEE 2004]**
(a) Arise from ER.
(b) Related to fat
(c) Single membrane bound structure
(d) Involved in photorespiration

5. Peroxisomes are rich in **[BHU 1999]**
(a) DNA (b) RNA
(c) Catalytic enzymes (d) Oxidative enzymes

6. Tonoplast is a **[CPMT 1996, 98; AFMC 1999; BHU 1999, 2006; BVP 2000; MP PMT 2002, 09; Odisha JEE 2005, 09; HP PMT 2005; DUMET 2009; Kerala PMT 2009]**
(a) Covering layer of golgi complex
(b) Covering layer of vacuoles
(c) Covering layer of microbodies
(d) Non-living cytoplasmic content

7. Vacuole in a plant cell **[CBSE PMT 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

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

9. Hyaloplasm of vacuole contains **[MP PMT 2004]**
(a) Air (b) Water
(c) Water and minerals (d) Nothing

10. DNA remains absent in **[MP PMT 2003, 09]**
(a) Chloroplast (b) Nucleus
(c) Peroxisomes (d) Chromosomes

11. What is degraded by Peroxisomes **[RPMT 1997]**
(a) Carbon dioxide (b) Hydrogen peroxide
(c) Litheum oxide (d) Carbon monoxide

12. Which one of the following is not considered as a part of the endomembrane system **[CBSE PMT (Mains) 2011]**

Or

Which of the following has a single unit membrane **[MP PMT 1999]**
(a) Vacuole (b) Lysosome
(c) Golgi complex (d) Peroxisome

13. Which one of the following is not a cell inclusion **[Odisha JEE 2011]**
(a) Crystal (b) Vacuole
(c) Starch (d) Fat droplets

14. Which of the following is correct in plant cell **[Odisha JEE 2008]**
(a) Bigger vacuole with rigid cell wall
(b) Centriole take part in cell division
(c) Centrosome are inactive in non-dividing cell
(d) Absence of cell membrane

15. In germinating seeds fatty acids are degraded *exclusively* in the **[CBSE PMT 2008]**
(a) Peroxisomes (b) Mitochondria
(c) Proplastids (d) Glyoxysomes

16. Glyoxysomes occur in **[Pune CET 1998]**
(a) Both plant and animal cells
(b) Plant cells only
(c) Animal cells only
(d) All types of cells

17. Some of the enzymes, which are associated in converting fats into carbohydrates, are present in **[CBSE PMT 1999]**

Or

Site of gluconeogenesis is **[Odisha JEE 2008]**
(a) Liposomes (b) Golgi bodies
(c) Microsome (d) Glyoxysomes

18. The osmotic expansion of a cell kept in water is chiefly regulated by **[AFMC 1999; CBSE PMT 2014]**
(a) Plastids (b) Ribosomes
(c) Mitochondria (d) Vacuoles

19. Which of the following parts of a cell is non-living **[CPMT 1993]**
(a) Centriole (b) Vacuole
(c) Ribosomes (d) Mitochondria

20. The fluid part of cell called *cell sap* is the **[AIIMS 1993; Manipal 2005]**
(a) Non-living contents of a cell
(b) Living contents of a cell
(c) Non-living contents of the vacuole of cell
(d) Living contents of the vacuole of cell

21. 'Peroxisome' is the microbody of a cell that helps in **[WB JEE 2016]**
(a) Removal of electron and associated hydrogen
(b) Removal of proton
(c) Conversion of carbohydrate into fat
(d) Conversion of carbohydrate into protein

Centrosomes / Centriole Cilia, Flagella and Microtubules

1. The plane of cell wall formation in a dividing cell is determined by **[J & K CET 2012]**

Or

The filaments associated with cilia and flagella are constituted by **[AIIMS 1994; MP PMT 2000]**
(a) Golgi apparatus (b) Microfilaments
(c) Microtubules (d) Endoplasmic reticulum

2. Centrioles and centrosomes are present in cells of **[MP PMT 1997; HPMT 2005]**
(a) Bacteria (b) Cyanobacteria
(c) Green plants (d) Animals

3. Function of centriole is **[CPMT 1996; Kerala CET 2002; MP PMT 2003; J & K CET 2005]**
(a) Formation of spindle fibres
(b) Formation of nucleolus
(c) Initiation of cell division
(d) Formation of cell plate

4. The function of centrosome is **[CBSE PMT 2000]**
(a) Inhibition of cell division
(b) Initiates cell division
(c) To increase protein synthesis
(d) None of these

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

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

7. A plant cell usually differs from an animal cell in the absence of **[MP PMT 1994, 2002; RPMT 2001; J & K CET 2002; DPMT 2003]**

Or

Plant cells normally lack **[AMU (Med.) 2012]**

Or

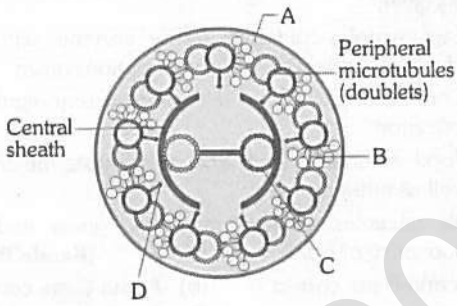
Which of the following organelles is devoid of DNA yet is capable of duplication **[MP PMT 2013]**
(a) Ribosomes (b) Centriole
(c) Mitochondria (d) E.R.

8. The usual axonemal arrangement of microtubules is **[AMU (Med.) 2012]**
(a) 6 pairs of doublets radially arranged at periphery with a pair of centrally located microtubules
(b) 6 pairs of doublets radially arranged at periphery with a single centrally located microtubule
(c) 9 pairs of doublets radially arranged at periphery with a pair of centrally located microtubules
(d) 9 pairs of doublets radially arranged at periphery with a single centrally located microtubule

9. The solid linear cytoskeletal elements having a diameter of 6 nm and made up of a single type of monomer are known as **[CBSE PMT 2014]**
(a) Intermediate filaments (b) Lamins
(c) Microtubules (d) Microfilaments

10. Number of protofilaments in microtubule is **[DPMT 2007]**
(a) 10 (b) 12
(c) 5 (d) 13

11. 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 **[NCERT]**
(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. Pattern of organisation of cilia and flagella is **[Kashmir MEE 1995; AMU (Med.) 2009]**
(a) 9 + 0 (b) 9 + 1
(c) 9 + 2 (d) 9 + 3

13. Flagella with single strand and composed of flagellin is found in **[J & K CET 2002]**
(a) Prokaryotes (b) Eukaryotes
(c) Both (a) and (b) (d) None of these

14. Basal bodies of cilia and flagella are derived from **[DPMT 1993]**
(a) Plasma membrane (b) Genes
(c) Centrioles (d) Lysosomes

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

16. In flagellar membrane which enzyme catalyses ATP **[DPMT 2007]**
(a) Cytoplasmic dynein (b) Asconic dynein
(c) Kinesis (d) Myosin

17. Microtubules are the constituents of **[NEET (Phase-I) 2016]**
(a) Cilia, Flagella and peroxisomes
(b) Spindle fibres, Centrioles and Cilia
(c) Centrioles, Spindle fibr and Chromatin
(d) Centrosome, Nucleoso and Centrioles

18. Prokaryotic flagella possess **CBSE PMT 1995; BHU 2000]**
(a) Helically arranged protein molecule
(b) Protein membrane enclosed fibre
(c) Unit membrane enclosed fibre
(d) Microtubular 9+2 membrane enclosed structure

19. Microtubule is involved in the **[CBSE PMT 1998]**
(a) Cell division (b) DNA recognition
(c) Muscle contraction (d) Membrane architecture

20. Tubulin protein occurs in **[MP PMT 2004; Odisha JEE 2012]**
(a) Rough endoplasmic reticulum
(b) Microtubules
(c) Thylakoids
(d) Digestive enzymes

21. An elaborate network of filamentous proteinaceous structures present in the cytoplasm which helps in the maintenance of cell shape is called **[CBSE PMT 2009; CBSE PMT (Mains) 2010]**
(a) Thylakoid (b) Endoplasmic Reticulum
(c) Plasmalemma (d) Cytoskeleton

22. Term basal body is associated with the development of **[CPMT 2002; RPMT 2005]**
(a) Cilia and flagella (b) Cell plate
(c) Phragmoplast (d) Kinetochore

23. The main function of microtubules is **[MP PMT 2006]**
(a) Protein synthesis
(b) Movement of cillia and flagella
(c) Formation of spindle fibres
(d) Both (b) and (c)

24. Match List I and List II and select the correct answer using the code given below the lists

	List I	List II
1.	Microtubules	Structural components of cilia
2.	Centrioles	Store hydrolytic enzymes
3.	Peroxisomes	Store oil protein and starch in plants

Option **[MP PMT 1993]**
(a) 1, 2 and 3 are correct
(b) 1 and 2 are correct, 3 is false
(c) 1 is correct, 2 and 3 are false
(d) 1 and 3 are correct, 2 is false

25. Which of the following statements regarding cilia is not correct **[CBSE PMT 2006]**
(a) Microtubules of cilia are composed of tubulin
(b) Cilia contain an outer ring of nine double microtubules surrounding two single microtubules
(c) The organised beating of cilia is controlled by fluxes of Ca^{2+} across the membrane
(d) Cilia are hair-like cellular appendages

26. Consider the following statements
(A) Plant cells have centrioles which are absent in almost all animal cells
(B) Ribosomes are the site of protein synthesis
(C) The middle lamella is a layer mainly of calcium carbonate which holds the different neighbouring cells together
(D) In animal cell steroidal hormones are synthesized by smooth endoplasmic reticulum
Of the above statements **[Kerala PMT 2010]**
(a) (A) and (B) only are correct
(b) (C) and (D) only are correct
(c) (B) and (D) only are correct
(d) (A) and (D) only are correct
(e) (B) and (C) only are correct

27. Microfilaments in eukaryotic cells are made up of **[DUMET 2010]**
(a) Actin (b) Albumin
(c) Globulin (d) Fibrin

28. The number of microtubules in a flagellum including those sharing three protofilaments with each other is **[DUMET 2010]**
(a) 11 (b) 20
(c) 22 (d) 10

Nucleus and Chromosomes

1. Controlling centre of cell is **[AFMC 1996]**
Or
The "master mind" of the cell is
(a) Nucleus (b) Nucleolus
(c) Mitochondria (d) Ribosome

2. Four different types of chromosomes but of the same size are serialized as **[MP PMT 1995]**
(a) Telocentric, metacentric, acrocentric, submetacentric
(b) Metacentric, acrocentric, submetacentric, telocentric
(c) Metacentric, submetacentric, acrocentric, telocentric
(d) Metacentric, telocentric, acrocentric, submetacentric

3. Basic structure of chromatin is composed of **[MP PMT 1999, 2001]**
(a) Non-histone proteins wrapped around DNA
(b) Histone proteins wrapped around DNA
(c) RNA wrapped around histones
(d) DNA wrapped around histones

4. The function of nucleolus is the synthesis of **[MP PMT 1994, 97; CPMT 2001; AIEEE (Pharmacy) 2009; CBSE PMT (Pre.) 2012]**
(a) DNA (b) m-RNA
(c) r-RNA (d) t-RNA

5. Nuclear material without nuclear membrane is observed in **[MP PMT 1994]**
(a) Bacteria and green algae
(b) Cyanobacteria and red algae
(c) Bacteria and cyanobacteria
(d) Mycoplasmas and green algae

6. The nucleoplasm is continuous with the cytoplasm of a cell through **[MP PMT 1994]**
(a) Centriole (b) Endoplasmic reticulum
(c) Nuclear pores (d) Golgi apparatus

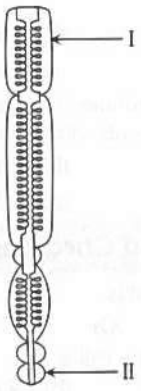
7. The term 'nucleolus' was coined by **[AFMC 2001]**
(a) R. Brown (b) H. Hooks
(c) Bowman (d) Hanstein

8. Karyolymph is a **[Pb. PMT 2000]**
(a) Nuclear sap (b) SPM membrane
(c) Nuclear pore (d) None of these

9. The nuclear spindle consists of **[MP PMT 1995, 98]**
(a) One type of fibre (b) Two types of fibres
(c) Three types of fibres (d) Four types of fibres

10. Karyology is the study of **[JIPMER 1993; AFMC 2008]**
(a) Cell (b) Nucleus
(c) Tissue (d) Genes

11. In the given diagram I and II indicate



[MHCET 2015]

(a) Chromomere and chromonemata
(b) Centromere and secondary constriction
(c) Secondary constriction and satellite
(d) Telomere and satellite

12. Spindle fibers attach on to **[NEET (Phase-I) 2016]**

(a) Telomere of the chromosome
(b) Kinetochore of the chromosome
(c) Centromere of the chromosome
(d) Kinetosome of the chromosome

13. Nucleoli are rich in

[CBSE PMT 1993; BHU 2001; MP PMT 2003]

(a) DNA and RNA (b) DNA, RNA and proteins
(c) DNA (d) RNA

14. Histone proteins found in nuclei of eukaryotes are **[CPMT 2000]**

(a) Acidic (b) Basic
(c) Neutral (d) Amphoteric

15. The structure of nuclear membrane facilitates

[CPMT 2002; RPMT 2005]

(a) Synapsis of homologous chromosomes at meiosis
(b) Nucleo–cytoplasmic exchange of materials
(c) Anaphasic separation of daughter chromosomes
(d) Organization of spindles

16. The nucleus has **[CBSE PMT 1993]**

(a) One membrane with pores
(b) Two membranes with pores
(c) Two membranes with pores through which substances do not pass
(d) Two membranes with pores through which macromolecules may pass

17. Spindle chromosomes have **[CBSE PMT 2000]**

(a) Centriole (b) Kinetochore
(c) Chromocentre (d) Chromomere

18. L-shaped chromosomes are called

[MP PMT 1999; BHU 2004]

Or

When the chromosome has a centromere nearer to one end of the chromosome resulting into one shorter and one longer arm, the chromosome is termed as **[AMU (Med.) 2012]**

(a) Sex chromosome (b) Acrocentric
(c) Telocentric (d) Sub-metacentric

19. The telomeres of eukaryotic chromosomes consist of short sequences of **[CBSE PMT 2004; AIIMS 2007]**

(a) Adenine rich repeats (b) Guanine rich repeats
(c) Thymine rich repeats (d) Cytosine rich repeats

20. Present in nucleolus is **[MP PMT 2010]**

(a) Golgi complex (b) Lysosome
(c) Mitochondria (d) Chromosome

21. A tetrad consists of **[MP PMT 1993]**

(a) Four non-homologous chromatids
(b) Four non-homologous chromosomes
(c) Two sets of homologous chromosomes, each with two chromatids
(d) Four homologous pairs of chromosomes

22. In nucleoplasm, a conspicuous body of spherical shape attached to a particular chromosome on a definite position is called **[AIIMS 1998]**

(a) Plasmid (b) Karyolymph
(c) Nucleolus (d) Nuclear reticulum

23. Identify the correct match between types of chromosomes and their descriptions

	Chromosomes		Position of centromere
A.	Metacentric	1.	At the tip
B.	Submetacentric	2.	Almost near the tip
C.	Acrocentric	3.	At the middle
D.	Telocentric	4.	Slightly away from the middle

Description **[Kerala PMT 2004]**

(a) A-1, B-3, C-2, D-4 (b) A-4, B-3, C-2, D-1
(c) A-1, B-2, C-3, D-4 (d) A-4, B-3, C-1, D-2
(e) A-3, B-4, C-2, D-1

24. Who showed that the nuclear membrane has many pores or circular structures or annuli

(a) Fawcell (b) Strasburger
(c) Butchen (d) Callan and Tomlin

25. Nucleolemma is a part of

(a) Nuclear membrane (b) Nuclear reticulum
(c) Nucleolus (d) Nucleoplasm

26. Minimum haploid numbers of chromosomes in plant kingdom **[RPMT 1999]**

(a) 3 (b) 2
(c) 1 (d) 4

27. The given diagram shows a chromosome

Which of the following table refers correctly to the chromosome **[NCERT]**

	No. of centromere	No. of Kinetochore	No. of arms
(a)	1	2	2
(b)	2	2	4
(c)	1	2	4
(d)	2	1	4

28. In a cell that is not dividing, the chromosomes are visible as a tangle of fine threads called **[MP PMT 1993]**

(a) Microtubules (b) Chromatin
(c) Microfilaments (d) Nucleotin

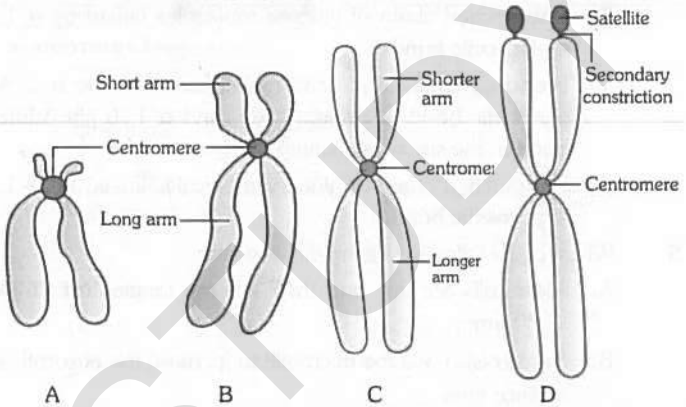
29. The nucleus is separated from surrounding cytoplasm by a nuclear membrane, which is **[MP PMT 1997; Pb. PMT 2004; BHU 2008]**

(a) Single layered with pores
(b) Single layered without pores
(c) Double layered with pores
(d) Double layered without pores

30. Nucleoproteins in a cell are synthesized in

(a) Outside the nucleolus (b) Nucleoplasm
(c) Nuclear membrane (d) Nucleolus

31. See the following figure and identify it **[NCERT]**



	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.

32. The sex chromosomes of plants were first discovered in **[CMC Vellore 1993]**

(a) Algae (b) Fungi
(c) Pteridophyta (d) Flowering plants

33. Which of the following are used to define the karyotype of a species

1. The number of chromosomes
2. The chromosome length
3. The positions of the centromeres

Code **[MP PMT 1993]**

(a) 1, 2 and 3 are correct (b) Only 1 and 2 are correct
(c) Only 2 and 3 are correct (d) Only 1 and 3 are correct

34. The part which does not take strain amongst the following is **[CPMT 1993]**

(a) Chromatid (b) Centromere
(c) Chromatin (d) Chromomere

35. DNA is mainly found in **[CBSE PMT 1999]**

(a) Nucleus only (b) Nucleus and cytoplasm
(c) Cytoplasm only (d) All of these

36. Which of the following is not contained in a eukaryotic nucleus **[MHCET 2002]**

(a) Nucleosome (b) Nucleolus
(c) Chromatin (d) Circular DNA molecuels

NCERT Exemplar Questions

1. A common characteristic feature of plant sieve tube cells and most of mammalian erythrocytes is **[NCERT]**

(a) Absence of mitochondria (b) Presence of cell wall
(c) Presence of haemoglobin (d) Absence of nucleus

2. Select one which is not true for ribosome **[NCERT]**

(a) Made of two sub units
(b) Form polysome
(c) May attach to mRNA
(d) Have no role in protein synthesis

3. Which one of these is not a eukaryote **[NCERT]**

(a) Euglena (b) Anabena
(c) Spirogyra (d) Agaricus

4. Which of the following dyes is best suited for staining chromosomes **[NCERT]**

(a) Basic Fuchsin (b) Safranin
(c) Methylene blue (d) Carmine

5. Different cells have different sizes. Arrange the following cells in an ascending order of their size. Choose the correct option among the followings

i. Mycoplasma ii. Ostrich eggs
iii. Human RBC iv. Bacteria

Options **[NCERT]**

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

6. Which of the following features is common to prokaryotes and many eukaryotes **[NCERT]**

(a) Chromosomes present
(b) Cell wall present
(c) Nuclear membrane present
(d) Sub cellular organelles present

7. Which of the following statements is true for a secretory cell **[NCERT]**
(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 nucleus

8. What is a tonoplast **[NCERT]**
(a) Outer membrane of mitochondria
(b) Inner membrane of chloroplast
(c) Membrane boundry of the vacuole of plant cells
(d) Cell membrane of a plant cell

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

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

11. Plastid differs from mitochondria on the basis of one of the following features. Mark the right answer **[NCERT]**
(a) Presence of two layers of membrane
(b) Presence of ribosome
(c) Presence of chlorophyll
(d) Presence of DNA

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

13. The stain used to visualise mitochondria is **[NCERT]**
(a) Fast green (b) Safranin
(c) Aceto carmine (d) Janus green

Critical Thinking

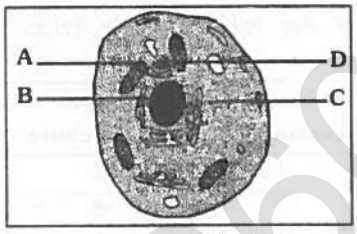
Objective Questions

1. Match the following with correct combination

Column I		Column II	
A.	Endoplasmic reticulum	1.	Stack of cisternae
B.	Spherosome	2.	Store oils or fats
C.	Dictyosomes	3.	Synthesis and storage of lipids
D.	Peroxisome	4.	Photorespiration
E.	Elaioplasts	5.	Detoxification of drugs

[Kerala PMT 2008]
(a) A – 5, B – 3, C – 1, D – 4, E – 2
(b) A – 5, B – 3, C – 2, D – 4, E – 1
(c) A – 2, B – 3, C – 1, D – 4, E – 5
(d) A – 3, B – 3, C – 1, D – 5, E – 2
(e) A – 3, B – 5, C – 1, D – 4, E – 2

2. The RER in the cell synthesised a protein which would be later used in building the plasma membrane. But it is observed that the protein in the membrane is slightly different from the protein made in the RER. The protein was probably modified in another cell organelle. Identify that organelle in the given diagram **[KCET 2009]**



(a) D (b) A
(c) B (d) C

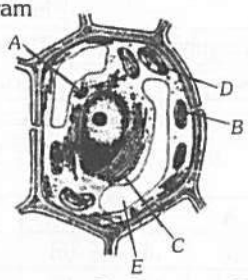
3. Cells obtained from an organism were homogenised and centrifuged. A test indicated that the cells contained glycogen. If you were asked to find out as quickly as possible whether the cells were from a plant or an animal, you would **[KCET 2006]**
(a) Examine the centrifuge for the presence of extracts of chloroplasts
(b) Answer immediately that the cells were from a plant source
(c) Examine the centrifuge for the presence of extracts of centrioles
(d) Answer immediately that the cells were from an animal source

4. Cellulose, the most important constituent of plant cell wall is made up of **[CBSE PMT 1998; AIIMS 2007]**
(a) Branched chain of glucose molecules linked by α 1, 6 glycosidic bond at the site of branching
(b) Unbranched chain of glucose molecules linked by α 1, 4 glycosidic bond
(c) Branched chain of glucose molecules linked by α 1, 4 glycosidic bond in straight chain and α 1, 6 glycosidic bond at the site of branching
(d) Unbranched chain of glucose molecules linked by α 1, 4 glycosidic bond

5. Which of the following statements are false
A. Most cells are tiny and their volume ranges from 1 to 1000 nm^3.
B. Some cells have the microvilli to increase the absorptive surface area.
C. All cells arise from pre–existing cells.
D. In plants, translocation of solutes is performed by xylem vessels and trachieds.
E. According to cell theory all cells arise from abiotic material.
[Kerala PMT 2006]
(a) A, C and E are false (b) A, D and E are false
(c) B, C and D are false (d) C, D and E are false
(e) A, B and C are false

6. Which of the following has centrioles **[MP PMT 1994]**
(a) Chromosomes (b) Spindle fibres
(c) Centrosomes (d) Centromeres

7. The diagram of the ultrastructure of a plant cell is given below. Identify the functions of the organelles labelled. A, B, C, D, E in the diagram **[KCET 2010]**



	A	B	C	D	E
(a)	Intracellular transport	Site of oxidative phosphorylation	Principle director of macromolecular traffic	Site of photoph-osphorylation	Storage of cell sap
(b)	Principle director of macromole-cular traffic	Site of oxidative phosphorylation	Intracellular transport	Site of photop-hosphorylation	Storage of cell sap
(c)	Site of photophos-phorylation	Storage of cell sap	Intracellular transport	Site of oxidative phosphor-rylation	Principle director of macromolec ular traffic
(d)	Storage of cell sap	Site of oxidative phosphorylation	Principle direction of macromolecular traffic	Site of photophosphor ylation	Intracellular transport

8. Disulphide bonds which acts as atomic staples to reinforce the conformation of proteins are found in **[AIEEE Pharmacy 2003]**

(a) Endoplasmic reticulum (b) Lysosome
(c) Golgi apparatus (d) Cytosol

9. Match the columns and identify the correct option **[AIPMT 2015]**

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

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

10. Consider the following statements

A. In prokaryotic cells a special membranous structure formed by the extension of the plasma membrane into the cell is known as polysome
B. The smooth endoplasmic reticulum is the major site for synthesis of glycoproteins
C. RuBisCo is the most abundant protein in the whole of biospshere
D. Mitochondria, chloroplasts and peroxisomes are not considered as part of endomembrane system

Of the above statements **[Kerala PMT 2012]**

(a) C and D alone are correct
(b) A and B alone are correct
(c) B and C alone are correct
(d) A and D alone are correct
(e) B and D alone are correct

11. Cellular organelles with membranes are **[AIPMT 2015]**

(a) Chormosomes, ribosome and endoplasmic reticulum
(b) Endoplasmic reticulum, ribosomes and nuclei
(c) Lysosomes, Golgi apparatus and mitochondria
(d) Nuclei, ribosomes and mitochondria

12. House-keeping proteins occur in **[AMU (Med.) 2010]**

(a) Endoplasmic reticulum (b) Golgi complex
(c) Cytoskeleton (d) All of the above

13. Consider the following statements and select the correct option

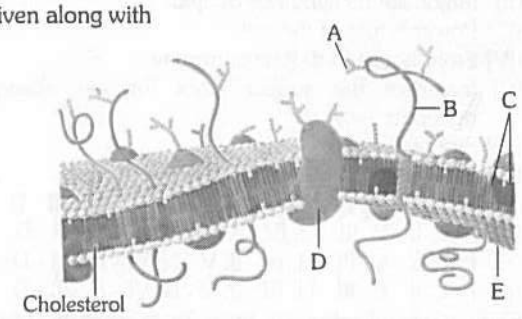
A. The endomembrane system includes plasma membrane, *ER*, Golgi complex, lysosomes and vacuoles
B. ER helps in the transport of substances, synthesis of proteins, lipoproteins and glycogen
C. Ribosomes are involved in protein synthesis
D. Mitochondria help in oxidative phosphorylation and generation of ATP **[Kerala PMT 2011]**

(a) B, C and D are correct (b) A - alone is correct
(c) B - alone is correct (d) C - alone is correct
(e) D - alone is correct

14. Which of the following four cell structures is correctly matched with the accompanying description **[AIIMS 2009]**

(a) Plasma membrane – Outer layer of cellulose or chitin, or absent
(b) Mitochondria – Bacteria like elements with 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. See the given diagram (cell membrane) and identify the components labelled A, B, C, D and E from the list (i) to (vii) given along with



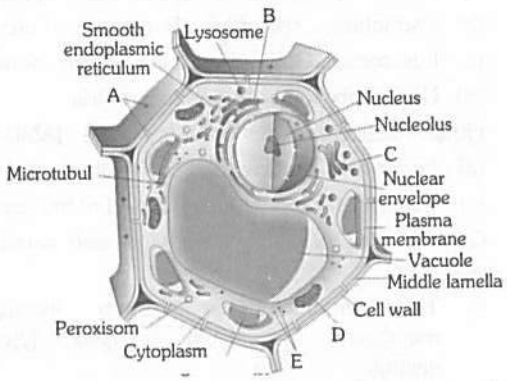
Components

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

The correct components are **[NCERT]**

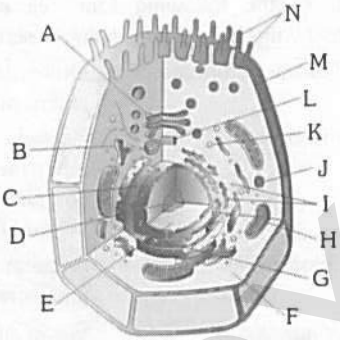
(a) A - (i), B - (ii), C - (iii), D - (vii), E - (v)
(b) A - (i), B - (ii), C (iii), D - (iv), E - (vi)
(c) A - (ii), B - (i), C - (iii), D - (iv), E - (v)
(d) A - (i), B - (ii), C - (iii), D - (iv), E - (v)

16. The given figure shows some of the missing structures in a plant cell (A - E). Identify the marked alphabets **[NCERT]**



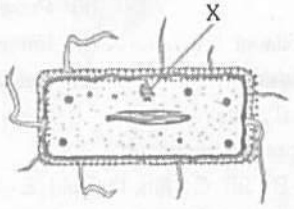
(a) A - Tight junction, B - Rough endoplasmic reticulum, C - Golgi apparatus, D - Mitochondrion, E - Ribosome
(b) A - Plasmodesmata, B - Smooth endoplasmic reticulum, C - Golgi apparatus, D - Mitochondrion, E - Ribosomes
(c) A - Desmosome, B - Rough endoplasmic reticulum, C - Golgi apparatus, D - Mitochondrion,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

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



(I) The structure replicates during mitosis and generates the spindle
(II) 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) Site for active ribosomal RNA synthesis **[NCERT]**
(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 - L, II - G, III - H, IV - J, V - N, VI - F, VII - D
(d) I - L, II - G, III - H, IV - J, V - N, VI - F, VII - D

18. 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 **[NCERT]**
(a) Mesosome (b) Ribosome
(c) Plasmids (d) Nucleoid

19. 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

[CBSE PMT 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)

20. Mitochondria and chloroplast are
(a) Semi-autonomous organelles
(b) Formed by division of pre-existing organelles and they contain DNA but lack protein synthesizing machinery

Which one of the following options is **correct**
[NEET (Phase-I) 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

21. Cytoskeletal network of a cell is built by a process called **[WB JEE 2016]**
(a) Triphasic polymerization (b) Biphasic polymerization
(c) Trendmilling (d) Dynamic instability

A R 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 : The number of mitochondria in a cell do not correspond to the function of the cell.
Reason : Mitochondria are common to both plant and animal cells. **[KCET 2006]**

2. Assertion : Mitochondria and chloroplasts are semiautonomous organelles.
Reason : They are formed by division of pre-existing organelles as well as contain DNA but lack protein synthesizing machinery **[AIIMS 2005]**

3. Assertion : A cell membrane shows fluid behaviour.
Reason : A membrane is a mosaic or composite of diverse lipids and proteins. **[AIIMS 2003]**

4. Assertion : Lysosomes help in photorespiration.
Reason : Lysosome have basic enzyme. **[AIIMS 1999]**

5. Assertion : Na^+- K^+ ATPase is an important membrane associated enzyme.
Reason : It helps in ion transfer across the membrane.

6. Assertion : The number of cells in a multicellular organism is inversely proportional to the size of body.
Reason : All the cells in the biological world are of same size. **[AIIMS 2002]**

7. Assertion : It is important that the organisms should have cell.
Reason : A cell keeps its chemical composition steady within its boundary. **[AIIMS 2002]**

8. Assertion : Leucoplasts give rise to other types of plastids.
Reason : Chromoplasts do not get changed to other types of plastids.

9. Assertion : Cell wall is not found in animal cell.
Reason : Animal cells are covered by cell membrane. **[AIIMS 2001, 13]**

10. Assertion : ER acts as a circulatory system.
Reason : ER functions as cytoskeleton.

11. Assertion : Eukaryotic cells have more DNA than prokaryotic cells.
Reason : Eukaryotes are genetically more complex than prokaryotes. **[MP PMT 1993]**

12. Assertion : Schleiden and Schwann were the first to observe the cells and to put forward cell theory.
Reason : The cells are always living unit. **[AIIMS 1994]**

13. Assertion : Cell membrane is semipermeable.
Reason : The constituent molecules can freely move in the membrane. **[AIIMS 1994]**

14. Assertion : Mitochondria is known as power house of cell.
Reason : ATP production takes place here. **[AIIMS 2000]**

Answers

Tools and Technique

1	a	2	a	3	a	4	a	5	c
6	a	7	a	8	a	9	e	10	a
11	a	12	d	13	d	14	c	15	d
16	b	17	a	18	a	19	c	20	b
21	a	22	b	23	a	24	b	25	d
26	a	27	b	28	c	29	b	30	b
31	d	32	b	33	c	34	c	35	c
36	d	37	a						

Cell Introduction and Cell Theory

1	a	2	d	3	b	4	b	5	c
6	d	7	d	8	b	9	d	10	c
11	a	12	c	13	d	14	b	15	d
16	c	17	d	18	d	19	c	20	b
21	d	22	e	23	d	24	d	25	a
26	d	27	d						

Cell wall

1	b	2	c	3	b	4	c	5	d
6	d	7	c	8	d	9	d	10	c
11	c	12	d	13	a	14	b	15	c
16	b								

Plasma Membrane

1	c	2	d	3	a	4	b	5	a
6	d	7	d	8	d	9	d	10	c
11	d	12	c	13	b	14	a	15	b
16	b	17	b	18	c	19	d	20	d
21	c	22	c	23	c	24	b	25	d
26	b	27	b	28	a	29	c	30	b
31	c	32	d	33	c				

Protoplasm and Cytoplasm

1	a	2	d	3	a	4	b	5	b
6	a	7	b	8	d	9	d	10	d
11	d	12	b	13	a				

Mitochondria

1	a	2	a	3	d	4	a	5	b
6	c	7	c	8	b	9	d	10	d
11	c	12	b	13	a	14	d	15	c
16	d	17	b	18	a	19	b	20	b
21	b	22	d	23	b	24	c	25	a
26	b	27	d	28	b	29	b	30	c
31	c	32	b						

Plastids

1	c	2	b	3	d	4	b	5	d
6	c	7	d	8	a	9	a	10	a
11	d	12	a	13	c	14	d	15	b
16	a	17	a	18	b	19	c	20	a

21	b	22	c	23	c	24	c	25	a
26	a	27	c	28	a	29	a	30	d
31	d	32	c	33	d				

Endoplasmic reticulum and Golgi body

1	d	2	a	3	a	4	c	5	b
6	c	7	b	8	c	9	a	10	b
11	c	12	d	13	a	14	d	15	c
16	b	17	b	18	a	19	c	20	a
21	b	22	b	23	c	24	b	25	a
26	c	27	a	28	b	29	a	30	c

Lysosome and Ribosomes

1	b	2	b	3	b	4	a	5	c
6	a	7	b	8	c	9	d	10	c
11	a	12	d	13	a	14	c	15	b
16	b	17	c	18	c	19	a	20	b
21	d	22	b	23	d	24	c	25	d
26	a	27	d	28	d	29	b	30	a
31	a	32	a	33	a	34	c	35	c
36	c	37	b	38	b	39	b	40	b

Sphaerosomes, Peroxisomes, Glyoxysomes and Vacuoles

1	d	2	a	3	d	4	d	5	d
6	b	7	d	8	b	9	c	10	c
11	b	12	d	13	b	14	a	15	d
16	b	17	d	18	d	19	b	20	c
21	a								

Centrosomes / Centriole Cilia, Flagella and Microtubules

1	c	2	d	3	a	4	d	5	a
6	c	7	b	8	c	9	d	10	d
11	d	12	c	13	a	14	c	15	a
16	b	17	b	18	a	19	a	20	b
21	d	22	a	23	d	24	c	25	c
26	c	27	a	28	b				

Nucleus and Chromosomes

1	a	2	c	3	b	4	c	5	c
6	c	7	c	8	a	9	c	10	b
11	d	12	b	13	b	14	b	15	b
16	d	17	b	18	d	19	b	20	d
21	c	22	c	23	e	24	d	25	a
26	b	27	c	28	b	29	c	30	a
31	d	32	d	33	a	34	b	35	a
36	d								

NCERT Exemplar Questions

1	a	2	d	3	b	4	d	5	a
6	b	7	b	8	c	9	a	10	d
11	c	12	a	13	d				

Critical Thinking Questions

1	a	2	a	3	d	4	d	5	b
6	c	7	b	8	a	9	a	10	a
11	c	12	d	13	a	14	d	15	d
16	d	17	b	18	a	19	c	20	c
21	d								

Assertion and Reason

1	e	2	c	3	a	4	d	5	a
6	d	7	a	8	b	9	a	10	b
11	a	12	d	13	b	14	a		

AS Answers and Solutions

Tools and Technique

1. (a) Differentiation capacity of compound microscope depends upon numerical aperture of the objective lens system and its wavelength (3900-7600 Å). Depending upon the type of visible light used, the resolving power of a light microscope ranges from 0.2 μm to 0.4 μm.

4. (a) Electron microscope is predominantly used for viewing of ultrastructure of cell and its organelles. Because it has great magnification and resolving power.

7. (a) Electron microscope can magnify the objects upto 2,00,000 times (now possible upto 2,50,000 – 4,00,000) and direct of objects is possible on this microscope. Presence of ribosomes (size 23nm in diameter) is revealed with the help of electron microscope.

23. (a) Agarose extracted from sea weeds finds use in gel electrophoresis.

28. (c) Electromagnetic lenses used in electron microscope having a coil of wire enclosed in soft iron casing.

30. (b) 1 Micrometer (μm) = $10^{-6}m$, $10^{-4}cm$, $10^{-3}mm$, $1000nm$.

32. (b) Phase contrast microscope is used to observe living cells and cell organs i.e., spindle fibres, pinocytosis, karyokinesis, cytokinesis etc.

33. (c) Autoradiography is a technique of studying the route of chemicals in chemical reactions taking place inside the cell and organisms with the help of radioactive isotopes *i.e.*, ^{14}C, ^{3}H, ^{32}P.

36. (d) Differential centrifugation : It is a mechanical separation of individual subcellular component from homogenate in centrifuge at different low speeds. Large/heavy/denser particles settle down first at lower speeds while the lighter/smaller/less denser particles do so at higher speeds in centrifuge.

Cell Introduction and Cell theory

1. (a) M.J. Schleiden and T. Schwann (1838 – 39) proposed cell theory.

2. (d) Viruses are not applicable to cell theory. They are made up of proteins and one of nucleic acids i.e., DNA or RNA. So they lack protoplasm, the essential part of the cell.

3. (b) The prokaryotic cells do not have nuclear membrane while eukaryotic cell have well organised nuclear membrane.

4. (b) Because cell organelles are absent in prokaryotes.

5. (c) In present time three types of cells are known *i.e.*, prokaryotic, mesokaryotic and eukaryotic.

8. (b) Virchow gave 'Omnis cellula a cellula' theory.

11. (a) In all living cells water forms 50-80% of total cell contents.

14. (b) Because the membrane which surrounds the vacuole is known as tonoplast.

17. (d) Cell organelles like mitochondria, golgi complex, E.R. and lysosomes etc. are present only in eukaryotes.

20. (b) Cell was discovered by Robert Hooke in 1965, when he observed tiny cavities bounded by definite walls in the sections of cork.

23. (d) Pleuro-pneumonia like organism (PPLO), *Mycoplasma gallisepticum* is having an average size of 0.150 μ.

Cell wall

1. (b) Through plasmodesmata, plasmoderm or a fine thread of protoplasm is passing.

10. (c) A polysaccharide is made up of many units of monosaccharides.

Plasma membrane

4. (b) Anthocyanin pigment cannot come outside due to impermeability of plasma membrane.

5. (a) Secondary wall situated near the plasma membrane. After the formation of primary wall.

7. (d) According to fluid mosaic model, the arrangement of lipid molecules in plasma membrane is head parallel. It means head of both lipid layer towards the outside.

9. (d) Surface of plasma membrane has the ion carriers which participates in exchange of ions.

16. (b) Lipoprotein cell membrane is found in both but ribosomes are of different kinds.

21. (c) Proline is a secondary amino acid which is not found in plasma membrane.

27. (b) There are many different proteins embedded in the membrane. Except for flip flop movements rest occurs. Choice (a) is amply demonstrated when the travelling proteins aggregate at sites of endocytosis. Choice (c) type of proteins can be enzymes which are confined to cetrain domains (for *e.g.*, present only on cell surface) choice (d) types are non-trasmembrane proteins.

31. (c) According to Singer and Nicolson model, proteins are dispersed in layer of phospholipid.

Protoplasm and Cytoplasm

3. (a) Ribosomes are the ribonucleoprotein particles of protoplasm.

5. (b) The *pH* of protoplasm is considered nearly as 7.

10. (d) Water is the basic component of the cytoplasm.

13. (a) The whole living material of cell is called protoplasm (According to Huxley, 1968).

Mitochondria

1. (a) Kolliker (1880), observed mitochondria in striated muscle cell of insect.

7. (c) Oxysomes (Elementary particles or inner membranes sub-units or F_1 particles); these are responsible for respiratory chain phosphorylation.

9. (d) Infolding of plasma membrane in bacteria are called mesosomes, which are analogous to mitochondria.

11. (c) Mitochondria without outer membrane is called as mitoplast.

13. (a) Cristae are finger like process projecting inwards.

14. (d) Mitochondria are called power house or storage batteries or ATP mills as these are sites of ATP formation (Respiration) through electron transport and oxidative phosphorylation which is used in various metabolic activities/functions of the cell.

16. (d) Mitochondria is responsible for the process of respiration which is a catabolic process. Mitochondria is a respiratory organelle where oxidation of stored food material takes place.

24. (c) Small DNA particles are present in mitochondria and chloroplast. They can duplicate and work as genetic material.

30. (c) Due to presence of 70*s* ribosome, RNA and *ds* circular DNA mitochondria is semiautonomous.

Plastids

1. (c) Plants are autotrophs and synthesize their food in the process of photosynthesis with the help of chloroplast (plastid).

2. (b) The green colour of plants is due to chlorophyll, which is found in chloroplast.

3. (d) Chromoplasts develop from proplastids, leucoplasts and chloroplasts. Transformation from chloroplasts is observed during ripening of fruits (*e.g.*, Tomato, Chilli) when they change their colour from green to reddish orange.

4. (b) Presence of cell wall and chlorophyll is characteristic feature of plants.

5. (d) Plastids are the characteristic feature of photosynthetic eukaryotes. Blue green algae and bacteria are prokaryotes and fungi are saprophytic eukaryotes.

8. (a) Thylakoids are bag like structure which stacked as coins one above the other and formed grana.

14. (d) Plastids are present in plant cells and absent in most of the animal cells.

16. (a) Thylakoids are structural and functional elements of chloroplast, which is made up of quantasome having 230 chlorophyll molecules.

20. (a) Guard cells are specialised chlorophyllous epidermal cells.

25. (a) The amyloplasts appear like proplastids. They store starch for a longer period.

27. (c) Lycopene is red coloured carotenoide present in chromoplast of tomato.

32. (c) The thylakoids of chloroplast are arranged in as stacks of coins or stacks of discs.

Endoplasmic reticulum and Golgi body

3. (a) The margins of cisternae of golgi body are slightly curved, so each cisternae has convex *cis* or forming face toward the nucleus and ER, whereas concave *trans* or maturing face towards the plasma membrane. It is believed that nuclear membrane and SER the source of small vesicles that fuse with the *cis* form.

8. (c) Golgi complex performs glycosyl transferase activity for addition of glycans on lipids and proteins.

9. (a) Because E.R. possesses ribosomes on their membrane which are responsible for protein synthesis.

13. (a) Mechanical supports, enzyme circulation are function of both *RER* and *SER* while the protein is synthesized by *RER* and detoxification of drugs by *SER*.

14. (d) Ribosomes are bounded on RER with the help of ribophorin.

17. (b) Endoplasmic reticulum gives support to the cell.

19. (c) RER has ribosome on which protein synthesis occurs.

22. (b) The formation/origin of new golgi body is always from endoplasmic reticulum, cisternae are similar in both.

23. (c) Fat synthesis is the main function of smooth endoplasmic reticulum.

24. (b) Smooth endoplasmic reticulum is the part of endoplasmic reticulum on which ribosomes are not present which takes part in lipid synthesis, fat synthesis, glycosylation of carbohydrates, steroid synthesis and detoxification. Whereas rough endoplasmic reticulum is the site of protein synthesis.

27. (a) Golgi and ER are often found associated to nuclear membrane.

30. (c) Golgi apparatus; because it secretes many types of metabolic enzymes.

Lysosome and Ribosomes

2. (b) Because lysosome is polymorphic (primary, secondary, tertiary, autophagic) and polyfunctional cell organelle.

5. (c) Cell wall die due to the release of enzyme of lysosome (autolysis).

13. (a) Ribosome is present in some cell organelles like mitochondria. Ribosomes are membraneless organelles which are made up of two sub-units and mRNA.

14. (c) Lysosomes exist as primary, secondary and tertiary lysosomes.

15. (b) Because it present hydrolytic enzyme, they can digest cell organelles and their parts.

16. (b) 55S ribosomes are found in mammalian mitochondria.

19. (a) Ribosomes are site of peptide bond formation.

21. (d) Ribosomes are also called palade particles.

22. (b) Bacterial ribosomes is 70 S type which resembles with mitochondrial ribosomes.

23. (d) Ribosomes are membraneless or without membraneous structure.

25. (d) Ribosomes are solid particles of protein and not made up of any membrane.

29. (b) Ribosomes are called site of protein synthesis because two sub-units of ribosomes are attached with the thread of mRNA. This mRNA contains anticodes for protein synthesis.

30. (a) Because lysosome contains digestive enzymes capable of lysis, thus it is a lytic body or suicidal bag.

35. (c) Ribosome is a combination of rRNA and protein.

Sphaerosomes, Peroxisomes, Glyoxysomes and Vacuoles

5. (d) Peroxisomes contain glycolic acid oxidase, which oxidises glycolic acid (a product of photosynthesis) to glyoxylic acid.

8. (b) Glyoxysomes are enzymes which play a critical role in lipid metabolism in seedlings. Hence they are supposed to be present in endosperm of castor as endosperm of wheat will posses starch.

10. (c) DNA not found in peroxisomes, ribosomes, ER, golgibody *etc.*

Centrosomes / Centriole Cilia, Flagella and Microtubules

3. (a) During cell division spindle fibres attached on centriole.

9. (d) Microfilaments are ultramicroscopic long, narrow cylindrical solid rods or protein filaments (actin protein) of approx 8 nm in dm.

10. (d) T.S. of microtubules shows array of 13 rows of subunit *i.e.*, protofilament having a diameter of 5 – 7 *nm*.

13. (a) The single stranded flagella occurs in prokaryotes *e.g.*, Bacteria *etc*. They contain only single stranded and not contain 9 + 2 system.

16. (b) The arms of microtubules contain a protein asconic dyenin. It is an ATPase enzyme which catalyzes hydrolysis of ATP to ADP, and transfers the released energy to ciliary/flagellar work.

21. (d) Cytoskeleton-Microtubule, Microfilament and Intermediate filaments.

23. (d) Microtubules play a role in formation and contraction of the spindle during chromosome movement as well as in cilliary and flagellar motion.

Nucleus and Chromosomes

7. (c) Nucleolus was discovered by Fontana. The term nucleolus was given by Bowman.

8. (a) Colloidal sap inside the nucleus is known as karyolymph or nucleoplasm.

15. (b) Holes in the centre of the nuclear pore provide the main channel through which water soluble molecules shuttle between the nucleus and cytoplasm. This channel also contains a protein called nucleoplasmin which facilitates nucleo-cytoplasm traffic through the pore.

17. (b) Chromosomes which adjoins with spindle fibres designated as spindle chromosomes. The position at which the spindle fibre is get attached, known as centromere or kinetochore.

19. (b) Eukaryotic telomeric DNA has been shown to consist of simple randomly repeated sequences characterized by clusters of G-residues in one strand and C-residues in the other. Another feature is a 3 overhang (12-16 nucleotides in length) of the G-rich strand.

Critical Thinking Questions

19. (c) Ribozyme is catalytic RNA.

Assertion and Reason

1. (e) Several work of cell carried out by mitochondria *i.e.*, ATP synthesis, aerobic respiration, maternal inheritance etc.

2. (c) Mitochondria and chloroplasts both are double membrane organelles. They are semi autonomous as both their structure and functions are partially controlled by nucleus of the cell and partially themselves. Both possess their own DNA and arises from pre-existing cells. Synthesis of many amino acids occurs in mitochondria. The first formed amino acids are glutamic acid and aspartic acid.

Also plastid manufactures some of its own proteins, enzymes and other chemicals because of the presence of 70s ribosomes which can help translate the coded information contained in *m*RNAs transcribed over chloroplast DNA.

DNA replication is the process of forming carbon copy of DNA. Whereas transcription is the formation of RNA over DNA template.

3. (a) With the help of freeze-fracture techniques in electron microscopy, the fluid mosaic model was put forward in 1970 by S.J. Singer and G.L. Nicolson. According to this model plasma membrane is composed of phospholipids, extrinsic proteins (integral proteins). Selective permeability of plasma membrane can be explained with this model.

4. (d) Lysosomes have hydrolytic enzymes. These have no role in photorespiration.

5. (a) Of all the membrane associated enzymes, Na^+,–K^+ ATPase is one of the most important because of its role in ion transfer across the plasma membrane. This enzyme is dependent on the presence of lipids and is inactivated when all lipids are extracted.

6. (d) Number of cells in a multicellular organism are directly proportional to the size of the body. On the other hand, it is a fact that cell vary greatly in their size. Mycoplasma cells are the smallest, ranging from 0.1 to 0.3μm, whereas human cells, generally range from 20 to 30μm. Nerve cells are the longest.

7. (a) Metabolic reactions of a living organism can occur only in a delicately balanced environment in the non-living organisms. The cells are the life supporting chambers which have such a special environment. A living cell keeps its chemical composition steady within its boundary.

8. (b) Leucoplasts can change to other types of plastids, but chromoplasts can not. Chromoplasts are formed either from leucoplasts or chloroplasts.

9. (a) Cell wall is characteristic feature of plant cells. Cell wall absent is animals. Animals cells covered by cell membrane.

10. (b) ER functions as cytoskeleton or intracellular and ultrastructural skeletal framework by providing mechanical support to colloidal cytoplasmic matrix. The ER may act as a circulatory system for intracellular circulation of various substances. Membrane flow may also be an important mechanism for carrying particles, molecules and ions into and out of the cells.

11. (a) Eukaryotic cells have more DNA than prokaryotic cells because in eukaryotic cells complex chromosomes composed of DNA and histone proteins. But in prokaryotic cells histone protein is absent.

12. (d) They are credited with cell theory but the cells are not always the living unit. Cell die and still remain functional such as horny cells in animal and xylem vessels in plants.

13. (b) Cell membrane is semi permeable as it allows continuous flow of selected materials across it as required from time to time. On the other hand, constituent molecules of cell membrane are free to move inside membrane.

14. (a) In mitochondria ATP production takes place. Therefore, mitochondria is called Power house.

Cell : The Unit of Life

SET Self Evaluation Test

1. The term lipochondria was suggested for **[MP PMT 2011]**
(a) Mitochondria (b) E. R.
(c) Golgicomplex (d) All of these

2. Nucleoid is **[MP PMT 2001]**
(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

3. Green potatoes are toxic due to **[MP PMT 2009]**
(a) Phytoalexins (b) Solanin
(c) Triazine (d) Hormones

4. Desmosomes are **[AFMC 2009]**
(a) Connecting bodies between cells
(b) Fat storage cells
(c) Pigment bodies
(d) None of these

5. What is lacking in an animal cell **[MP PMT 2011]**
(a) Plasmodesmata (b) 80s ribosomes
(c) Centriole (d) All of these

6. Importance of mitochondria in respiration was first discovered by **[RPMT 1999]**
(a) S. Madani (b) Meves
(c) Michaelis (d) Barbergan

7. Electron transport system in mitochondria is located in **[MP PMT 1997; MHCET 2001]**
(a) Outer membrane (b) Inter-cristae space
(c) Inner membrane (d) Inner membrane space

8. What is the proportion of lipids in chloroplast **[MP PMT 2011]**
(a) 5-10% (b) 40-50%
(c) 1-2% (d) 20-30%

9. Match the following

A. Bacteria	1. Synthesis and storage of lipids
B. Sphaerosomes	2. Idiogram
C. Chloroplasts	3. Glycocalyx
D. Karyotype	4. Thylakoids

[Kerala PMT 2006]
(a) $A-3, B-2, C-4, D-1$
(b) $A-3, B-1, C-2, D-4$
(c) $A-4, B-3, C-2, D-1$
(d) $A-1, B-2, C-3, D-4$
(e) $A-3, B-1, C-4, D-2$

10. Phragmoplast is **[JIPMER 2002]**
(a) Cell plate formed by endoplasmic reticulum and products of dictyosome during cytokinesis
(b) Cell membrane formed by endoplasmic reticulum, golgi bodies and secretory vesicles during cytokinesis
(c) Plastid capable of fragmentation
(d) Plastid capable of duplication

11. One of the most common enzyme found in peroxisome is **[Odisha PMT 2002]**
(a) Hydrolase (b) Catalase
(c) Dehydrogenase (d) Reductase

Answers

1	c	2	c	3	a	4	a	5	a
6	c	7	c	8	d	9	e	10	a
11	b								

* * *