DAY NINE

Cell : The Unit of Life

Learning & Revision for the Day

- The Cell Theory
- Some Important Facts Related to Cells
- Types of Cells
- Components of a Cell
- Cell Organelles : Structure and Functions
- Nucleus
- Chromosome

- A **cell** (Latin, *cellula* – a small compartment) is the smallest unit that exhibit the properties of life and is known as the structural and functional unit of all living beings.
- **Robert Hooke** (1665) first saw and **Antony van Leeuwenhoek** described the first living cell. **Robert Brown** later discovered the nucleus. The invention of the microscope and its improvement as electron microscope has revealed all the structural details of the cell.
- The properties exhibited by a cell are
  - Cells are complex and highly organised structures containing many internal components.
  - Cells contain a genetic blueprint.
  - Cells arise from the division of other cells, i.e. pre-existing cells.
  - Cells acquire and utilise energy to perform chemical and mechanical activities.
- The branch which deals with the study of cell and its organelles is called **cytology**. Various scientists have worked on the structural and functional properties of a cell that led to several discoveries in the field of cytology.
- Some of the related discoveries are discussed below

Important events in discovery of cell

Year	Name of the scientist	Discovery
1665	Robert Hooke	Discovered the cells in sections of cork (Father of Cytology).
1675	Antony van Leeuwenhoek	Discovered microscopic 'animalcules' in pond water.
1831	Robert Brown	Discovered nucleus in cells of orchid roots.
1839	Theodor Schwann	Concluded that cells of plants and animals are similar structures, and that plant cells have a cell wall which is absent in animal cells.
1855	Rudolf Virchow	Stated that all cells arise from pre-existing cells, i.e. '*Omnis cellula-e-cellula*'.

The Cell Theory

MJ Schleiden and **T. Schwann**, based on their respective observations, formulated the cell theory in 1839. This was modified by **Rudolf Virchow** (1855) to explain the formation of new cells. The cell theory can be summarised as

1. All living organisms are made up of one or more cells.
2. The cell is the basic structural and functional unit of life.
3. All cells arise from pre-existing cells.

Virus as Exception to Cell Theory

Apart from other organisms, virus can reproduce using its own genetic material only inside the host which provides it with raw materials and biosynthetic machinery. Outside the host cell, they are just non-living inert particles. Due to this fact, virus can be considered as an exception to the cell theory.

Some Important Facts Related to Cells

- Mature nerve cells are incapable of division. Liver cells and muscle cells retain mitotic ability but seldom divide normally.
- PPLOs (Pleuro Pneumonia Like Organisms) such as *Mycoplasma gallisepticum* is the smallest living cell, measuring about 0.1-0.3 µ.
- Ostrich egg is the largest living cell with 6 inches in diameter.
- Nerve fibres are longest cells in animals measuring more than 90 cm long.
- The cells and their compounds like cell organelles are measured in terms of the fractions of a millimetre, because of their extremely small size.
- All eggs are unicellular in nature.
- *Acetabularia* is the largest, unicellular, uninucleate, green alga, which consists of a cap and stalk. Its body cannot be divided into cells.
- Unicellular organisms have single cell, e.g. yeast, diatoms, *Acetabularia*, while in multicellular organisms, number of cells varies individual to individual, e.g. green algae (*Pandorina*) have fixed number of cells (i.e. 8, 16, 32), whereas a man of 80 kg weight has 60 thousand billion cells. There are around 10^{12} cells in 1 kg.

Types of Cell

Depending upon the nature of nucleus and the basic structure, cells are of following two types

Prokaryotic Cell

- Cell that does not have a nuclear membrane and nucleoid represents the genetic material, is called a prokaryotic cell.
- Most prokaryotic cells, specifically the bacterial cell have a cell envelope consisting of an outer glycocalyx, followed by peptidoglycan cell wall and plasma membrane.

Eukaryotic Cell

- Cell with advanced nucleus, (i.e. a well developed nuclear membrane) is called a eukaryotic cell.
- The eukaryotic cells have a more elaborate internal organisation as compared to the prokaryotic cell consisting of cell membrane enclosing various cell organelles.

Types of Eukaryotic Cell

The eukaryotic cells are of two types, i.e. **plant cells** and **animal cells**. Most of the organelles and other structures are common to both animal and plant cells.

The differences between plant and animal cell are as follows

Differences between plant and animal cell

Characters	Animal Cells	Plant Cells
Cell wall	Absent	Present (formed of cellulose
Shape	Round (irregular shape)	Rectangular (fixed shape)
Centrioles	Present in all animal cells	Only present in lower plant forms
Vacuole	One or more small vacuoles (much smaller than plant cells)	One, large central vacuole taking up 90% of cell volume.

The differences between prokaryotic and eukaryotic cell can be summarised as given below in the table

Differences between prokaryotic and eukaryotic cell

Feature	Prokaryotic cell	Eukaryotic cell
Cell size	Small (0.1-2.0 µm)	Large (10-100 µm)
Envelope	Glycocalyx, cell wall, cell membrane	Cell wall and cell membrane (animal cells lack cell wall)
Nuclear organisation	Organised nucleus absent, instead nucleoid is found	Organised nucleus present; differentiated into envelope, nucleoli, nucleoplasm, etc.
DNA and histones	Naked, not associated with histones protein	Nuclear DNA associated with histones protein
Cellular processes	Transcription and translation occur in cytoplasm	Transcription occurs in nucleus while translation in cytoplasm
Plasmids	May be present	Absent altogether
Ribosomes	70S type	80S type usually however, 55S type may occur in mitochondria and chloroplast
Cell organelles	Absent	Present (membrane bound)

Feature	Prokaryotic cell	Eukaryotic cell
Microbodies	Absent	Present
Cytoskeleton	Absent	Present
Flagella	Not arranged	9 + 2 arrangement with differentiation into axoneme and sheath.
Cell wall	Present with muramic acid	Without muramic acid

Types of Cells on the Basis of Capability of Division

Generally in the body following three types of functional cells are found

- **Undifferentiated cells or Stem cells** are unspecialised cells, which give rise to new cells by mitotic divisions. These go to form new tissues or in the maintenance of existing tissues. Examples for these are the Malpighian layer in the epidermis of skin, the germinal epithelium found in the gonads, the stem cells in the bone marrow, the meristematic tissue in plants, etc.
- **Differentiated cells** are specialised cells, that carry on specific functions. They have a specific form, structure and function, which normally do not change. Differentiation increases the functional efficiency through division of labour.
- **Dedifferentiated cells** are cells which can revert back to an embryonic or undifferentiated state. Dedifferentiation is seen in dicot plants, particularly at the time of secondary growth. It is also seen in the process of regeneration that involves the ability of an animal to develop the lost parts of its body. Such a phenomenon is seen in coelenterates and echinoderms. The capacity of cells to undergo dedifferentiation indicates that cells retain their complete genetic information.

NOTE
- Undifferentiated cells are also called the **meristematic** cells.
- Differentiated cells are post-mitotic specialised cells.
- Cellular totipotency is the ability of a living cell to develop into complete organism.
- Steward (1957) first provided the evidence of cellular totipotency.

Components of a Cell

The component of a cell can be broadly categorised in following three categories

1. **Outer covering**, i.e. cell wall and cell membrane.
2. **Protoplasm**, i.e. the fluid content of cell.
3. **Cell organelles**, i.e. structures that float within the protoplasm like, mitochondria, chloroplast, ribosome, etc.

Cell Wall

- It is the outermost, rigid protective and non-living structure.
- Prokaryotic cells like bacteria, cyanobacteria and eukaryotic cells like algae, fungi and plants contain a cell wall outside the cell membrane.
- The cell wall is rigid, which maintains shape and size of the cell apart from providing mechanical support.
- In certain fungi, most algae and higher plants, cellulose (a polymer of glucose, in which glucose molecules are joined by β, 1-4-glycosidic bonds) is the main component of cell wall.
- In eubacteria, the characteristic cell wall material is peptidoglycan or murein, a complex of oligosaccharide and proteins.
- In bacteria, the cell wall is made up of peptidoglycans. The sugars found in bacterial cell wall are N-acetyl glucosamine and N-acetyl muramic acid.
- N-Acetyl Glucosamine (NAG) and N-Acetyl Muramic acid (NAM) are linked by β, 1,4-linkage.
- D-amino acids which are present in bacterial cell wall, render it resistant to the action of proteases, which acts on more commonly occurring L-amino acids.
- In fungi, a cell wall is composed of chitin, a nitrogen containing polysaccharide.
- Chitin is a structural polymer, which consists of N-acetyl glucosamine monomers.

Structure of Cell Wall

In plants, the cell wall is composed of four layers

1. **Middle lamella** is the outermost layer of cell wall that separates the wall of two adjacent cells.
   - It is made up of calcium pectate and magnesium pectate.
   - The basic chemical unit of pectin is the carbohydrate, galacturonic acid, which is capable of forming salts with Ca and Mg.
   - The fruit softens and attains maturity due to the loss of pectate in middle lamella.
2. **Primary cell wall** is initial wall, which develops on both sides of middle lamella.
   - It is made up of cellulose, hemicellulose, pectin and lignin. Hemicellulose is made up of pentoses, i.e. arabinose, xylose and hexoses (i.e. mannose and galactose).
   - Cellulose and hemicellulose are synthesised by Golgi apparatus.
3. **The primary cell wall** is followed by **secondary cell wall** which is made up of cellulose, hemicellulose and lignin.

- In wood, secondary wall is impregnated by lignin. Lignin is a coniferyl alcohol. It is the main constituent of woody tissues. In cork cells, suberin is impregnated in secondary wall and forms it impervious to water.
- Cutin is also a secondary wall material, generally found on epidermal cells of leaf and stem.

4. **Tertiary cell wall** is found beneath the secondary cell wall in tracheids.
   - The continuity of cytoplasm from cell to cell is maintained through cytoplasmic connections called **plasmodesmata**. Plasmodesmata facilitate movement of molecules between adjoining cells.
   - Cell wall is formed from cell plate, which is also referred as phragmoplast during cytokinesis.

Functions of Cell Wall

- Cell wall reduces the rate of transpiration, this happens due to the deposition of cuticle which makes it impermeable to water.
- Intercellular movement of materials and cytoplasmic continuity is maintained with the help of pits that are present in the cell wall.
- It provides shape and mechanical strength to the cell. It protects the cell from chemical actions.

Cell or Plasma Membrane

- It is a thin, delicate, elastic and living boundary. The term 'cell membrane' was given by C Nageli and C Cramer (1855).
- This term is used when cell is observed under simple microscope. However, when this boundary was observed under electron microscope, a clear differentiation of 2 layers was noticed. Out of these, one layer was the real membrane (called **plasma membrane** or **plasmalemma** by Plower in 1931) which was surrounded by layer of cell cement.

Structure of Plasma Membrane

To explain the arrangement of constituents of plasma membrane following models have been proposed

1. Bilayer Model

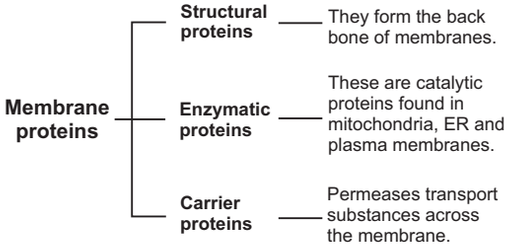
- Bilayer model of cell membrane was proposed by **Danielli** and **Davson** in 1935.
- As per Danielli and Davson model, plasma membrane is made up of three layers, i.e. a bimolecular lipid layer is sandwiched between two layers of proteins.
- This model is the oldest model of plasma membrane structure. It is based upon the surface tension studies.

2. Unit Membrane Model

- **Robertson** (1959) proposed **unit membrane** concept based upon the electron microscopic study on **myelin**.
- As per Robertson model, all the biological membranes have a unit membrane construction.
- Robertson's model failed to explain permeability and transport properties of membrane.

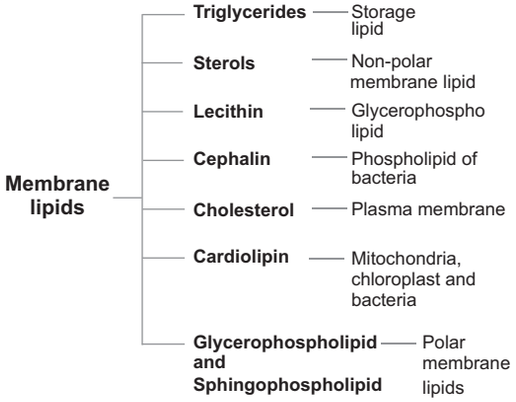
3. Fluid Mosaic Model

- Fluid mosaic model was proposed by **SJ Singer** and **GL Nicolson** in 1970. As per this model, plasma membrane is composed of phospholipids, extrinsic proteins (peripheral proteins) and intrinsic proteins (integral proteins). The Singer and Nicolson fluid mosaic model differs from Robertson's model in the arrangement of proteins.
- As per fluid mosaic model, the correct sequence of plasmalemma is P (protein), L (lipid). Fluid mosaic model is the most reasonable explanation of the structure of plasma membrane.
- There are two types of proteins in plasma membrane, i.e. extrinsic and intrinsic proteins.
- The **peripheral** or **extrinsic** proteins are loosely bound at the polar surface of lipid bilayer while **intrinsic** or **integral** proteins penetrate deeply into the lipid layers.
- The integral proteins which project on both surfaces are called **transmembrane** or **tunnel proteins**.
- **Selective permeability** of the membrane can be explained by this model. Plasma membrane is generally made up of protein, lipid and small amount of carbohydrates.



Classification of membrane proteins

- Plasma membrane contains about 40% lipid and 60% protein.



Classification of membrane lipids

- The carbohydrates of plasma membranes are mainly hexose, hexosamine, fructose and sialic acid, which are present in the form of glycoproteins and glycolipids.

- **Phytosterol** is the major component of plant cell membrane. **Cholesterol** is the major component of animal cell membrane.

Functions of Cell Membrane

The cell membrane performs following important functions

- **Exocytosis** is the ejection or secretion of a substance from a cell. This substance is enclosed in a membranous vesicle, which fuses with the plasma membrane and ruptures, releasing the substance to the exterior.
- **Endocytosis** (pinocytosis) takes place when plasma membrane sink beneath an external fluid drop. Membrane edges fuse, forming a fluid- filled vesicle.
- **Phagocytosis** (cell eating) takes place when a large external particle is surrounded and becomes enclosed in a vesicle (clathrin–coated).
- **Passive transport** takes place when a substance moves across the membrane from higher to lower concentration. Here, no energy is used.
- **Active transport** is said to take place when a substance moves against the concentration gradient and ATP is utilised in the process.

Protoplasm (*Proto*–first; *plasm*–fluid)

- The complex fluid part of the cell is called protoplasm. Protoplasm is viscous and colourless. It is the living part of a cell, i.e. it can perform all the vital activities.
- Protoplasm can be differentiated into two regions, namely nucleoplasm, i.e. protoplasm of the nucleus and cytoplasm, i.e. extranuclear protoplasm.
- Cytoplasm occupies the major part of the cell. It is limited on outside by plasma membrane and on the inside by nuclear membrane.
- Cell organelles such as mitochondria, endoplasmic reticulum, Golgi apparatus, etc., are found embedded in the cytoplasm.

NOTE

- Some non-living substances that lack biological properties and are produced by the protoplasm itself constitute the deutoplasm, e.g. yolk bodies, lipid droplets, secretory granules, pigments, etc.
- **Protoplast** It is the cell without cell wall.

Cell Organelles : Structure and Functions

Cell organelles are mainly of two types

1. **A membrane bound organelle** is an organised cellular structure that carries out a unique function. It includes endoplasmic reticulum, Golgi complex, mitochondria, chloroplasts and lysosomes.

   The **endomembrane system** consists of nuclear envelope endoplasmic reticulum, Golgi complex, lysosomes and vacuoles suspended in the cytoplasm.

2. **Non-membranous cell organelles** suspended in the cytoplasm and associated with the membranous organelles are various kinds of structures that are not composed of phospholipids and proteins arranged in sheets. It includes ribosomes, centrosomes, microbodies, microtubules and microfilaments.

Different cell organelles are discussed below

1.Mitochondria

- These were first observed by **Kolliker** in 1850. **R Altman** named mitochondria as the bioblast.
- The present name mitochondria was coined by **C Benda**.
- Mitochondria are cylindrical bodies with an average diameter of 0.2-1 µ and ordinarily 3-10 µ in length.
- Yeast cells have one giant, branched mitochondria. An average cell may have 200 to 800 mitochondria. In some protozoans, e.g. *Chaos chaos* there may be as many as 5,00,000 mitochondria in a cell. A single mitochondrion is found in *Microsterias,* an unicellular green alga.
- Mitochondria show variable shapes, so they show **pleomorphism**. Mitochondria remain absent in prokaryotic cells and mature human RBCs.
- Mitochondria are oval and rod-shaped organelles formed by a double membrane. The inner membrane is folded into projections called **cristae**, which contain numerous tiny particles called **oxysomes** or **F_1 particles**.
- Mitochondrial DNA is small, simple, double-stranded circular or linear. The size of mitochondrial genome is very much large in plants than in animals.
- These are **semi-autonomous** cell organelles because they contain DNA as well as ribosomes and are able to synthesise proteins.
- According to scientific observation, the new mitochondria have originated by the growth and division of pre-existing mitochondria.
- Mitochondria are believed to be evolved by a process of endosymbiosis from ancient symbiotic bacteria capable of carrying out oxidative metabolism. **Mesosome** of bacteria is analogous to mitochondria.
- The number of mitochondria correlates with the metabolic activity of cell. The active cells have more mitochondria compared to the less active. Plant cells have fewer mitochondria than animal cells.
- **Krebs' cycle** takes place in the matrix of mitochondria. **Circular DNA** and 70 S ribosomes are present in the matrix.
- In mammalian mitochondria, 55 S ribosomes are found. Inner membrane of cristae bears F_1 particles or oxysomes, which have a spherical head, subtended by a stalk and a base (F_0). F_1 subunit of oxysome is an integral protein embedded in the membrane lipid. F_1-F_0 combination functions as ATP synthetase catalysing ATP synthesis.

- Outer mitochondrial membrane contains less amount of cardiolipin and more amount of phosphatidyl inositol and cholesterol. It also contains stalkless particles called **sub-units of Parson**.
- Inner membrane contains cytochromes of respiratory chain cyt.-*b*, *c*, *a* - a_3, quinone, ubiquinone, FMN, NAD, DPN and FAD, etc.
- Mitochondria are sites of cellular respiration, oxidative phosphorylation, synthesis of heme protein, cytochrome, myoglobin, etc.
- Life of mitochondria is not more than 5 days.
- Mitochondria are yellowish due to riboflavin.
- The DNA of mitochondria is rich in G : C ratio. 70% of total enzymes of a cell are found in mitochondria.

Functions of Mitochondria

- Main sites for cellular respiration (oxidative phosphorylation), also called ATP mills of the cells.
- Regulate calcium ion concentration in the cell.
- Provide intermediate for synthesis of chlorophyll, cytochrome, steroids, etc.

2. Plastid

This term was given by **E Haeckel** (1865). They are the largest cell organelles.

These are double membrane bound structures, mainly used for trapping radiations and storage purposes. Plastids are small bodies found freely in most plant cells. These are absent in fungi, certain bacteria, algae and multicellular animals. The plastids can be categorised into

(i) **Leucoplast** (colourless plastids) are of three types
- **Aleuroplasts** or **Proteinoplasts,** which store proteins, e.g. in maize.
- **Elaioplasts** or **Oleosomes,** which store lipid or fats, e.g. in endosperm cells of castor seeds.
- **Amyloplasts**, which store starch, e.g. in potato tubers.

(ii) **Chromoplasts** (coloured plastids) are responsible for the process other than photosynthesis. The various forms found in algae are as follows
- **Rhodoplasts** are found in red algae (Rhodophyceae), which contain chlorophyll-a, chlorophyll-*d*, *r*-phycoerythrin and *r*-phycocyanin.
- **Phaeoplasts** are found in brown algae (Phaeophyceae), which contain chlorophyll-*a*, chlorophyll-*c* and fucoxanthin (brown pigment).
- **Chromatophores** are found in cyanobacteria (blue-green algae) and bacteria.
- Chromatophores of blue-green algae contain chlorophyll-*a*, *c*-phycocyanin (phycobilins) and *c*-phycoerythrin. Chromatophores of photosynthetic bacteria contain bacteriochlorophyll ($C_{55}H_{74}O_6N_4Mg$) or chlorobium chlorophyll.

(iii) **Chloroplasts** (green plastids) are double membrane structure. Both membranes are smooth. The inner membrane is less permeable than outer but rich in proteins, especially carrier proteins.
- Space between the outer and inner membrane is called periplastidial space. Matrix is present in the centre. **Thylakoids** are closed flat bags of membranes containing pigments.
- Many membranous tubules are found in stroma called **stroma lamellae** or **fret channels**, which interconnect thylakoids of different grana.
- Plastids show **cytoplasmic inheritance** or **organellar inheritance** or **extrachromosomal inheritance**.
- Chloroplast have a double helical, circular DNA called cp DNA with an average lenght of 45 µm (about 135000 basepairs).
- Chloroplast genome is larger than mitochondrial genome. Chloroplast DNA have split genes but their introns differ from nuclear genes of eukaryotes. Chloroplasts have 70S ribosomes, which are inhibited by chloramphenicol as in bacteria and do not inhibited by cyclohexamide, which inhibits 80S ribosomes.
- Initiation of protein synthesis takes place in chloroplasts by **methionyl *t*RNA**.
- Chloroplasts are semi-autonomous cell organelles, which contain the four components necessary for autonomy, i.e. DNA, DNA polymerase, RNA polymerase and a protein synthesizing system.
- The chloroplasts never originated *de novo*. Chloroplasts multiply by fission. Chloroplasts are believed to be originated from cyanobacteria (blue-green algae) due to endosymbiosis followed by extensive endosymbiotic gene transfer from cyanobacterium to the eukaryotic host nucleus.
- DNA of chloroplast is called **plastidome**.

Functions of Plastids

- All important processes of photosynthesis (light and dark reaction) occur within the chloroplast.
- The granum is the site of light reaction and the stroma is the site for dark reaction.
- Chloroplast participate in photorespiration and is the seat of glycolic acid synthesis.
- In certain cases, they get metamorphosed into chromoplasts, e.g. in fruits of tomato.

3. Endoplasmic Reticulum (ER)

- It is a branched membranous network spread all over the cell, connecting at places to the cell membrane and nuclear membrane also.
- It was discovered by **Porter** *et al*, in 1945. It is of two types–**smooth ER** (sarcoplasm), i.e. without ribosomes and **rough ER** (ergastoplasm), i.e. with ribosomes.

- ER functions mainly as an intracellular transport channel.
- ER consists of an intercommunicating system of channels, made up of membranous sacs, i.e. cisternae, vesicles and narrow tubules.
- ER helps in protein synthesis indirectly as it provides space for ribosomes. The protein synthesised, enters into the ER and then to Golgi complex or directly secreted out of the cell. Nuclear membrane → Pores → ER → Golgi complex → Plasmalemma → Outside.
- About 30-60% of total membranous system is made up of endoplasmic reticulum.
- Microsomes are the microbodies formed by the breakage of ER ends.

Differences between SER and RER

SER (Smooth Endoplasmic Reticulum)	**RER** (Rough Endoplasmic Reticulum)
It is mainly formed of vesicles and tubules.	It is mainly formed of cisternae and a few tubules.
It is engaged in the synthesis of glycogen, lipids and steroids.	The reticulum takes part in the synthesis of proteins and enzymes.
SER gives rise to spherosomes.	It helps in the formation of lysosomes through the agency of Golgi apparatus.
Pores are absent so that materials synthesised by SER do not pass into its channels.	RER possesses narrow pores below its ribosomes for the passage of synthesised polypeptides into ER channels.
SER is often peripheral. It may be connected with plasmalemma.	It is often internal and connected with nuclear envelope.
Ribophorins are absent.	RER contains ribophorins for providing attachment to ribosomes.
It may develop from RER through loss of ribosomes.	It may develop from outer membrane of nuclear envelope.

Functions of ER

- Lipid, protein and glycogen synthesis.
- It is involved in the formation of glycosomes and peroxisomes.
- ER helps in membrane biosynthesis, cell secretions, transport of ions and molecules.
- Other functions include synthesis of cholesterol and steroid, detoxification of toxins, giving mechanical strength to the cell.

4. Golgi Body

- It was discovered by **Camillo Golgi** (1898), an Italian scientist, while studying the nerve cell in Barn Owl. Golgi complex of plants is known as **dictyosome**. Term 'dictyosome' was coined by **Perroncito** in 1910.
- **Plant cells** have several hundred Golgi bodies. Collectively, the Golgi bodies are referred to as **Golgi complex**.
- There are three major components of Golgi body, i.e. flattened sacs or cisternae, clusters of tubules and vesicles and large vacuoles filled with amorphous or glandular content.
- According to **Dalton** and **Felix** (1954), Golgi vesicles have three regions, i.e. the *cis*, the medial and the *trans* region.
- The vesicles fuse with *cis* region of Golgi complex and protein progress from *cis* to medial and finally to the *trans* region. The secretory vesicles leave the *trans* region and move towards plasma membrane.
- The cisternae, closest to the plasma membrane are called *trans* face and the cisternae closet to the centre of the cell are called *cis* face. The medial cisternae are in between the *trans* and *cis* cisternae.

Functions of Golgi Body

- Golgi bodies perform several functions, these include absorption of toxic compounds, synthesis of polysaccharides, acrosome formation, glycolipid synthesis, fluid regulation and lysosome formation.
- Also, protein transfer, secretion of glycoprotein, fluid regulation, cell wall formation, egg covering, absorption of lipids are some other functions that are completed with the help of Golgi bodies.

5. Lysosomes

- These were discovered by **de Duve** in 1949 biochemically in rat liver, homogenate by ultracentrifugation. He also introduced term lysosome and said them **suicidal bags of cell** as they contain hydrolytic enzymes.
- They are organelles bound by a single membrane, found in all animal cells except mature mammalian RBCs. Generally, they are absent in plant cells.
- They enclose lytic enzymes (i.e. about 50 hydrolases), which can dissolve old and worn out cell organelles and if necessary the entire cell itself. They bring about digestion of useful organic substances present in the cell (i.e. intracellular digestion).
- Most hydrolytic enzymes of lysosomes function at acidic pH, i.e. approximately 4.6-5.0, which is maintained by a proton pump that accumulates H^+ inside the lysosome.
- Lysosomes may bud off from M face (maturing face) of Golgi complex. They are common in WBC, liver, spleen, etc.
- Lysosomes release hydrolases in damaging and ageing cells to digest them by a process called **autolysis**. Thus, lysosomes are called autophagosomes or scavenger of cells. They also help in cell division.

6. Ribosomes

- These are granule-like non-membranous cell organelles, discovered by **Palade** (1955) in animal cell but **Robinson** and **Brown** (1953) in plant cells and the term 'ribosome' was introduced by **Roberts** in 1958.
- Ribosomes are found in both prokaryotic and eukaryotic cells. In a eukaryotic cell, ribosomes occur freely in the cytoplasm, attached to the surface of Endoplasmic Reticulum (ER), in the matrix of organelles like mitochondria and chloroplasts. These are also found attached to the nuclear membrane and inside the nucleolus.
- S stands for **Svedberg unit**, which is a measure of particle size related to the speed at which the particles are settled when subjected to centrifugation ($S = 1 \times 10^{-13}$ second).
- Each ribosome consists of two sub-units. The sub-units occur separately in the cytoplasm and join to form a ribosome particle only at the time of protein synthesis.

Source	Ribosome Type	Sub-unit	
		Small	Large
Prokaryotes	70S	30S	50S
Eukaryotic cytosol	80S	40S	60S
Mitochondria	55S	30S	40S
Chloroplast	70S	33S	50S

- The two subunits of ribosomes are associated with the help of Mg^{2+} ions (at 0.001 m concentration). If the Mg^{2+} concentration is less in cytoplasm, the two units of ribosome separate. Whereas, if Mg^{2+} concentration is increased ten times, the ribosomes unite and form a **Dimer** (120 S).
- The larger subunit of each ribosome has two cavities, i.e, – P (Polypeptidyl site) and A (Aminoacyl site).
- Ribosomes found in the cytoplasm in free form are called **monosomes**. Many ribosomes may be associated with *m*RNA to form polyribosomes or polysomes.
- Ribosomes are called as organelles within an organelle.
- Ribosomes are chemically composed of *r*RNA and proteins. Lipids are absent in ribosomes. Ribosomes are the site of protein synthesis (translation); hence they are commonly described as protein factories of cell. In eukaryotes, the site of synthesis of most *r*RNA is the nucleolus.

7.Vacuoles

- These are the single membrane bound structures found in the cytoplasm. It contains water, sap, excretory products, other materials which are not useful for the cell. It is bound by a single membrane called **tonoplast**.
- In plant cells, the vacuoles can occupy up to 90% of the volume of cell. Anthocyanin and anthoxanthins are found in plant vacuoles. Gas vacuoles have been reported in prokaryotes.
- In *Amoeba*, the contractile vacuole is important for excretion and osmoregulation. In many cells as in protists food vacuoles are formed by engulfing the food particles.
- Several types of enzymes including hydrolases are found in vacuoles. These play an important role in cell metabolism and may act as storage compartments and also as lysosomes.
- These are also involved in turgor and detoxification.

8. Microbodies

These are small cell organelles bound by single membrane, which absorb molecular oxygen and take part in oxidation other than those involved in respiration. They are of two types

- **Peroxisomes** were discovered by **de Duve** (1965).
  - Peroxisomes are single membrane bound organelles. The presence of large amount of the enzyme catalase in the peroxisomes rapidly converts the toxic hydrogen peroxide into harmless H_2O and O_2.

$$2H_2O_2 \xrightarrow{\text{Catalase}} 2H_2O + O_2$$

  - In mesophyll cells of leaves, peroxisomes, interact with mitochondria and chloroplast to take part in photorespiration.
  - Unusual substances or xenobiotics, which cannot be metabolised by normal enzymes are broken down inside peroxisome.
- **Glyoxysomes** were discovered by **Beevers** (1919) in endosperm of germinating seeds. They are found in fat-rich plant cells and are involved with fat metabolism through glyoxylate cycle.

9. Cytoskeleton

- The cytoskeletal fibres include microtubules (25 nm in diameter), intermediate filaments (10 nm in diameter) and microfilaments (8 nm in diameter). Microtubules are hollow cylindrical structures built from tubulin (α and β) protein. The mitotic spindle involved in separating the replicated chromosomes during mitosis is assembly of microtubules.
- Microtubules have many functions, such as chromosomal movement, intracellular transport of materials, cellular motility, ciliary and flagellar movement of organelles within cell and they establish asymmetrics, polarities and changes of shape in higher plants.
- The drug colchicine inhibits the polymerisation of microtubules, thus blocking cell processes such as cell division that depends on functioning of microtubules.
- Microfilaments are made of actin and have a mechanically supportive function. Through their interaction with myosin, the microfilaments form contractile assemblies that are involved in various intracellular movements such as cytoplasmic streaming and the formation of membrane invaginations.

10. Cilia and Flagella

- These are hair-like outgrowths of the cell membrane with the 9+2 pattern organisation.
- Cilia are small structures, which work like oars, causing the movement of either the cell or the surrounding fluid.
- Flagella are comparatively longer and responsible for cell movement.
- The prokaryotic bacteria also possess flagella but these are structurally different from that of eukaryotic flagella.
- The cilium (sing.) and flagellum (sing.) are covered with plasma membrane.
- Their core is called **axoneme**.
- Cilia and flagella originate from **basal bodies** or **blepharoplast**.

11. Centrosome

- It is a cell organelle containing two cylindrical structures called **centrioles**.
- Both the centrioles in a centrosome lie perpendicular to each other in which each has an organisation like the cartwheel. They are made up of nine, evenly spaced peripheral fibrils of tubulin protein.
- The central part of the proximal region of the centriole is also proteinaceous and called the **hub**, which is connected with the tubules of the peripheral triplet by radial **spokes** made of protein.
- The centrioles form the basal body of cilia or flagella and spindle fibres that give rise to spindle apparatus during cell division in animal cells.

Nucleus

- It was discovered by **Robert Brown** (1853), its study is known as **Karyology**.
- German biologist **J Hammerling** (1934) proved that nucleus is the controlling centre of cell, based on grafting experiment by using two species of unicellular, green algae *Acetabularia*.
- Based on the number of nucleus present, cells may be **mononucleate, binucleate** or **polynucleate**.
- Polynucleate condition may be because of fusion of a number of cells, which resulted into syncytium (e.g. coconut endosperm) or by free nuclear divisions without cytokinesis which resulted into coenocyte (commonly found in plants).
- In mammalian erythrocytes (RBCs) and sieve tubes of plants, nucleus is present during early stage but degenerates at maturity.

Structure of Nucleus

The four main parts of nucleus are

(i) **Nuclear membrane** is a membrane enclosing nucleoplasm, which is made up of two unit membranes. The space between these two membranes is called **perinuclear space**. The continuity of nuclear envelope is broken by minute pores called **nuclear pores**.

(ii) **Nuclear sap** or **nucleoplasm** consists of nucleic acids, enzymes, lipids, minerals and proteins (histone and non-histone). It contains nucleolus and chromatin material.

Nucleoplasm is the site of enzyme activities and synthesis of DNA, RNA and ribosomal sub-units.

(iii) **Nucleolus** is a dense, spherical colloidal body without any limiting membrane, which remains attached with nuclear organising chromosomes.

- It was discovered by **Fontana** (1781) and termed as nucleolus by **Bowman** (1840).
- The main function of nucleolus is the synthesis of ribosomal RNA, hence it is called storehouse of RNA. It also plays an important role in cell division.

(iv) **Chromatin** The chromatin (meaning coloured fibres) are fine fibres composed of DNA, some proteins and transcribing RNA.

- The proteins associated with chromatin are mainly histone proteins. These are positively charged basic proteins mainly composed of lysine and arginine. However, in certain types of sperms, histones are replaced with protamines.
- During cell division, the chromatin condenses and becomes thick enough to form specialised structures called **chromosomes**.
- It was observed that when chromosomes are stained with basic dyes like acetocarmine or fuelgen stain, two types of regions can be observed hetero-chromatin region and euchromatin region.

Differences between heterochromatin and euchromatin

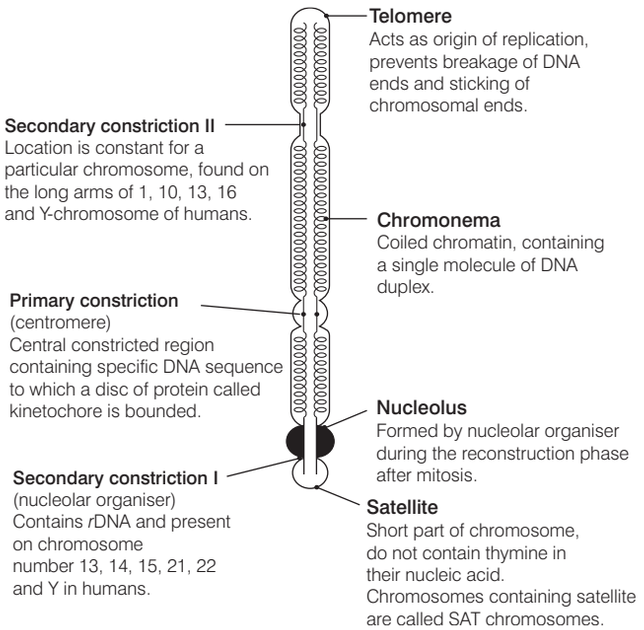
Heterochromatin	Euchromatin
They are the compactly coiled regions of the chromatin.	They are loosely coiled regions of the chromatin.
It stains deeply.	It stains less deeply.
It contains more DNA and replicates at the end of S-phase of mitotic cycle.	It contains less DNA and replicates during the early stages of S-phase.
It is less stable being affected by temperature, sex, age (of parents), proximity to the centromere, etc.	It is more stable.
It is genetically inert and does not transcribe. Thus, not involved in protein synthesis.	It is genetically active and is usually under active transcription. Thus, actively participates in protein synthesis.
It has low crossover frequency.	It has high crossover frequency.

Chromosome

- The size and number of chromosomes vary from species to species and genera to genera. Usually, within a species, these remain constant.
- The length and thickness of a normal chromosome varies from 1-30 μ and 0.2-2 μ, respectively. The shape of chromosomes varies according to the stages of cell division.
- Somatic cells always possess two sets of chromosomes. Thus, they are diploid ($2n$). On the other hand, gametic cells usually possess one set of chromosomes, i.e. haploid (n).
- In humans, there are 46 chromosomes (i.e. 22 pairs somatic chromosomes +X and Y-sex chromosomes). X-chromosome is partly euchromatic and partly heterochromatic, whereas Y-chromosome is heterochromatic.
- Chemically, chromosomes are nucleoproteins containing DNA (about 40%), RNA (1-10%), histones or basic proteins (40-50%) and non-histone proteins (about 10%).

Structure of Chromosome

Each chromosome have two halves or chromatids, which are attached to each other by centromere or primary constriction.



Outline structure of a typical chromosome

Classification of Chromosome

(i) On the basis of number of centromere, the chromosomes are

- **Acentric** without centromere.
- **Monocentric** with a single centromere.
- **Dicentric** with two centromeres.
- **Polycentric** with many centromeres diffused along the entire length.

(ii) On the basis of position of centromere, the chromosomes are categorised as

- **Metacentric chromosomes** The centromere is median in position. It appears V-shaped during anaphasic movement.
- **Submetacentric chromosomes** The position of centromere is submedian. Thus, one arm of chromosome is smaller and the other one is larger. It appears 'L-shaped' during anaphasic movement.
- **Acrocentric chromosomes** Centromere is subterminal in position. Thus, one arm is very small and other is very long.
- **Telocentric chromosomes** Centromere is terminal, in position, i.e. situated in the telomeric region. Telocentric chromosomes are very rare. In humans, none of the chromosome is telocentric.

Some Special Types of Chromosomes

These are given below

(i) **Lampbrush chromosomes** are present in primary oocyte nuclei of vertebrates as well as of invertebrates. These are 800-1000 μ long and maximum length of these chromosomes were observed in urodele amphibians, i.e. 1 mm (1000 μ).

- The main axis of chromosome consists of DNA on which chromomeres are present. From each chromomere, 1-9 loops arise in pairs. The loop axis is again made up of DNA, which is surrounded by a matrix on both sides made of RNA and proteins.
- Due to the presence of paired loops, these chromosomes appear like lampbrush and hence, called lampbrush chromosomes.

(ii) **Polytene chromosomes or Salivary gland chromosomes** were discovered by **EG Balbiani** (1881).

- These are found in salivary gland cells of insects of order–Diptera.
- These are Giant chromosomes (up to 2000 μ or 2 mm), characterised by somatic pairing due to which the number of chromosomes appears half of normal somatic cells. Polytene chromosomes have distinct **dark bands** and **light bands**. Polytene chromosomes form puffs or loops (in region of dark bands), which are called **Balbiani puffs** or **Balbiani rings,** where synthesis of *m*RNA takes place.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 Which among the following is not a prokaryote?
(a) *Nostoc* (b) *Mycobacterium*
(c) *Saccharomyces* (d) *Oscillatoria*

2 Which of the following cell organelles are non-membranous and found in both prokaryotic and eukaryotic cells?
(a) Lysosomes (b) Microbodies
(c) Ribosomes (d) Vacuoles

3 In eubacteria, a cellular component that resembles eukaryotic cells is
(a) nucleus (b) ribosomes
(c) cell wall (d) plasma membrane

4 Which of the following is not true of a eukaryotic cell?
(a) It has 40S type of ribosome present in the mitochondria
(b) It has 40S type of ribosome present in the cytoplasm
(c) Mitochondria contain circular DNA
(d) Membrane bound organelles are present

5 Genes present in the cytoplasm of eukaryotic cells are found in
(a) mitochondria and inherited *via* egg cytoplasm
(b) lysosomes and peroxisomes
(c) Golgi bodies and smooth endoplasmic reticulum
(d) plastids and inherited *via* male gamete

6 Select the mismatch. → NEET-II 2016
(a) Gas vacuoles – Green bacteria cells
(b) Large central vacuoles – Animal cells
(c) Protists – Eukaryotes
(d) Methanogens – Prokaryotes

7 Which of the following components provides sticky character to the bacteria? → NEET 2017
(a) Cell wall (b) Nuclear membrane
(c) Plasma membrane (d) Glycocalyx

8 Secondary cell wall grows by
(a) deamination (b) calcitonin
(c) opposition (d) None of these

9 Which of the following is not correctly matched for the organism and its cell wall degrading enzyme? → NEET 2013
(a) Plant cells–Cellulase (b) Algae–Methylase
(c) Fungi–Chitinase (d) Bacteria–Lysozyme

10 The plasma membrane consists mainly of
(a) phospholipids embedded in protein bilayer
(b) protein embedded in a phospholipid bilayer
(c) protein embedded in a polymer of glucose molecules
(d) protein embedded in carbohydrate bilayer

11 The membrane is selectively permeable. Many molecules can move across the membrane without any requirement of energy, this is called
(a) active transport (b) osmosis
(c) passive transport (d) diffusion

12 Fluid mosaic model is the most accepted model for plasma membrane structure. It shows that
(a) quasi fluid nature of lipid enables lateral movement of proteins within the overall bilayer
(b) lateral movement within the membrane is measured as its fluidity
(c) fluid nature of membrane is important for growth formation of intercellular junctions, secretion, endocytosis, cell division, etc
(d) All of the above

13 Which of the following cell organelles is responsible for extracting energy from carbohydrates to form ATP? → NEET 2017
(a) Lysosome (b) Ribosome
(c) Chloroplast (d) Mitochondrion

14 Enzymes found attached to inner membrane of mitochondria instead of matrix is/are
(a) succinic dehydrogenase
(b) cytochrome oxidase
(c) Both (a) and (b)
(d) malic dehydrogenase

15 Which of the following statements regarding mitochondrial membrane is not correct?
(a) The outer membrane is permeable to all kinds of molecules
(b) The enzymes of the electron transfer chain are embedded in the outer membrane
(c) The inner membrane is highly convoluted forming a series of infoldings
(d) The outer membrane resembles a sieve

16 In chloroplasts, chlorophyll is present in the
(a) outer membrane
(b) inner membrane
(c) thylakoids
(d) stroma

17 Which of the following is not correctly matched?
(a) Amyloplast – Store fats
(b) Elaioplasts – Store oils
(c) Aleuroplasts – Store proteins
(d) Chloroplasts – Contain photosynthetic pigments

18 The structures that are formed by stacking of organised flattened membranous sacs in the chloroplasts are → CBSE-AIPMT 2015

(a) cristae (b) grana
(c) stroma lamellae (d) stroma

19 The osmotic expansion of a cell kept in water is chiefly regulated by → CBSE-AIPMT 2014

(a) mitochondria (b) vacuoles
(c) plastids (d) ribosomes

20 Water soluble pigments found in plant cell vacuoles are → NEET-I 2016

(a) chlorophylls (b) carotenoids
(c) anthocyanins (d) xanthophylls

21 The Golgi complex participates in

(a) respiration in bacteria
(b) formation of secretory vesicles
(c) fatty acid breakdown
(d) activation of amino acid

22 Important site for the formation of glycoproteins and glycolipids is

(a) Golgi apparatus (b) plastid
(c) lysosome (d) vacuole

23 Mitochondria and chloroplast are

I. semi-autonomous organelles.
II. formed by division of pre-existing organelles and they contain DNA but lack protein synthesising machinery.

Which one of the following options is true? → NEET-I 2016

(a) II is true, but I is false (b) I is true, but II is false
(c) Both I and II are false (d) Both I and II are true

24 Select the correct matching in the following pairs. → CBSE-AIPMT 2015

(a) Smooth ER – Oxidation of phospholipids
(b) Smooth ER – Synthesis of lipids
(c) Rough ER – Synthesis of glycogen
(d) Rough ER – Oxidation of fatty acids

25 The Golgi complex plays a major role → NEET 2013

(a) in digesting proteins and carbohydrates
(b) as energy transferring organelles
(c) in post-translation modification of proteins and glycosidation of lipids
(d) in trapping the light and transforming it into chemical energy

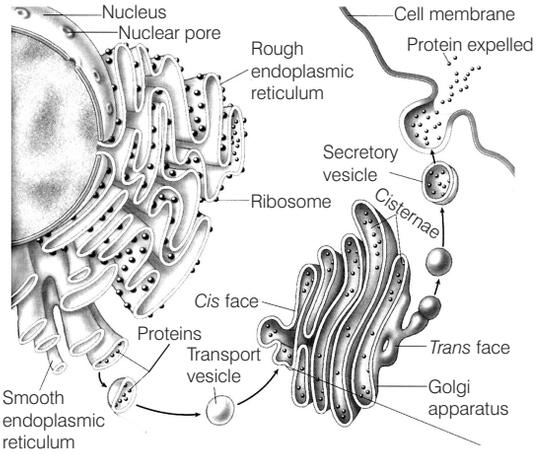
26 Major site for synthesis of lipid is → NEET 2013

(a) SER (b) Symplast
(c) nucleoplasm (d) RER

27 Mechanical support, enzyme circulation, protein synthesis and detoxification of drugs are functions of

(a) ER
(b) ribosomes
(c) dictyosomes
(d) chloroplast

28 Which of the following organelles in the figure correctly matches with its function? → NEET 2013



(a) Golgi apparatus, protein synthesis
(b) Golgi apparatus, formation of glycolipids
(c) Rough endoplasmic reticulum, protein synthesis
(d) Rough endoplasmic reticulum, formation of glycoproteins

29 A cell organelle containing hydrolytic enzyme is → NEET-II 2016

(a) lysosome (b) microsome
(c) ribosome (d) mesosome

30 Which one of the following cell organelles is enclosed by a single membrane? → NEET-II 2016

(a) Chloroplast (b) Lysosome
(c) Nucleus (d) Mitochondria

31 Three of the following statements regarding cell organelles are correct, while one is incorrect. Identify the incorrect statement.

(a) Lysosomes are double membraned vesicles budded off from Golgi apparatus and contain digestive enzymes
(b) ER consists of a network of membranous tubules and helps in transport, synthesis and secretion
(c) Leucoplasts are bounded by two membranes, lack pigment but contain their own DNA and protein synthesising machinery
(d) Spherosomes are single membrane bound and are associated with synthesis and storage of lipids

32 What is true about ribosome?

(a) The prokaryotic ribosomes are 80S, where S stands for its 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

33 Flagella of prokaryotic and eukaryotic cells differ in

(a) type of movement and placement in cell
(b) location in cell and mode of functioning
(c) microtubular organisation and type of movement
(d) microtubular organisation and function

34 The solid linear cytoskeletal elements having a diameter of 6 nm and made up of a single type of monomere are known as → CBSE-AIPMT 2014

(a) microtubules (b) microfilaments
(c) intermediate filaments (d) lamins

35 Microtubules are the constituents of → NEET-I 2016

(a) spindle fibres, centrioles and cilia
(b) centrioles, spindle fibres and chromatin
(c) centrosome, nucleosome and centrioles
(d) cilia, flagella and peroxisomes

36 Microtubule is involved in the

(a) cell division
(b) membrane architecture
(c) muscle contraction
(d) DNA recognition

37 Microtubules are absent in

(a) mitochondria (b) flagella
(c) spindle firbes (d) centriole

38 Bacterial cell may be motile or non-motile. The surface structure, which plays major role in motility is

(a) flagellum (b) pili
(c) fimbriae (d) All of these

39 Select the incorrect statement. → NEET-II 2016

(a) Bacterial cell wall is made up of peptidoglycan
(b) Pili and fimbriae are mainly involved in motility of bacterial cells
(c) Cyanobacteria lack flagellated cells
(d) *Mycoplasma* is a wall-less microorganism

40 Which of the following is not a function of cytoskeleton in a cell?

(a) Intracellular transport
(b) Maintenance of cell shape and structure
(c) Support of the organelle
(d) Cell motility

41 Centriole is a reproducing organelle in the cytoplasm of

(a) plant cells
(b) animal cells
(c) *Euphorbia cells*
(d) *Chrysanthemum* cells

42 Which of the following is true for nucleolus? → NEET 2018

(a) It takes part in spindle formation
(b) It is a membrane-bound structure
(c) Larger nucleoli are present in dividing cells
(d) It is a site for active ribosomal RNA synthesis

43 Chromatin contains

(a) only DNA
(b) basic proteins called histones only
(c) non-histone proteins
(d) All of the above

44 DNA is denatured by

(a) heat (b) acid
(c) DNA polymerase (d) Both (a) and (b)

45 Match the following columns. → CBSE-AIPMT 2014

	Column I		Column II
A.	Centriole	1.	Infoldings in mitochondria
B.	Chlorophyll	2.	Thylakoids
C.	Cristae	3.	Nucleic acids
D.	Ribozymes	4.	Basal body cilia or flagella

Codes

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

Directions (Q. Nos. 46-47) *In each of the following questions a statement of Assertion is given followed by a corresponding statement of Reason just below it. Of the statements, mark the correct answer as*

(a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion
(b) If both Assertion and Reason are true, but Reason is not the correct explanation of Assertion
(c) If Assertion is true, but Reason is false
(d) If both Assertion and Reason are false

46 **Assertion** The true nucleus is generally absent in *E. coli* and other prokaryotes.

Reason An undifferentiated, unorganised fibrillar nucleus without any limiting membrane is observed in prokaryotic cells.

47 **Assertion** Eukaryotic cells are provided with tremendous mechanical support and are able to carry out directed movements.

Reason There are three principal types of protein filaments– actin filament, microtubules and intermediate filaments, which give the mechanical support to cell.

DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1 A chromosome whose terminal centromere is capped by telomere is
(a) metacentric (b) telocentric
(c) submetacentric (d) acrocentric

2 Satellite of chromosomes is
(a) rich in RNA and deficient in DNA
(b) rich in DNA and deficient in RNA
(c) rich protein
(d) lacks DNA

3 The prokaryotic flagella possess
(a) unit membrane enclosed fibre
(b) protein membrane enclosed fibre
(c) '9+ 2' membrane enclosed structure
(d) helically arranged protein molecule

4 Several ribosomes may attach to a single *m*RNA and form a chain called
(a) polysome or polyribosome
(b) monosome or monoribosome
(c) mesosome or inclusion bodies
(d) cyanophycean granules or gas vacuoles

5 In an animal cell, the synthesis of proteins occurs
(a) exclusively on ribosomes present in cytosol
(b) on ribosomes present in nucleolus
(c) exclusively on ribosomes attached to nuclear envelope and ER
(d) on ribosomes present in cytosol and the mitochondria

6 Comparing small and large cells, which statement is correct?
(a) Small cells have a small surface area per volume ratio
(b) Exchange rate of nutrients is fast with large cells
(c) Small cells have a large surface area per volume ratio
(d) Exchange rate of nutrients is slow with small cells

7 Extranuclear inheritance is a consequence of the presence of genes in
(a) mitochondria and chloroplast
(b) endoplasmic reticulum and mitochondria
(c) ribosomes and chloroplast
(d) lysosomes and ribosomes

8 Which of the following statements is correct?
(a) The genetic material of prokaryotes is not enclosed in a cell
(b) Ribosomes were discovered by Palade in plant cells
(c) Ribosomes are DNA–protein complexes
(d) Balbiani's rings are found in polytene chromosomes

9 A phospholipid molecule is amphipathic and produces two layers coming in contact with H_2O. The head of phospholipid molecule is
(a) at an angle of 40°
(b) towards the outer side
(c) between the surfaces
(d) embedded in protein molecules

10 Which of the following is not true for a eukaryotic cell?
(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

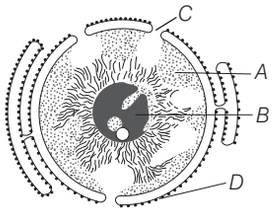
11 Which of the following statements is true for a secretory cell?
(a) Golgi apparatus is absent
(b) Rough Endoplasmic Reticulum (RER) is easily observed in the cell
(c) Only Smooth Endoplasmic Reticulum (SER) is present
(d) Secretory granules are formed in nucleus

12 Identify the incorrect statement.
(a) Glycoprotein and glycolipids of plasma membrane facilitate cellular recognition and adhesion
(b) The semipermeable membrane surrounding the vacuole is called tonoplast
(c) Gametes of plants are without cell wall
(d) Ingestion of solid particles is called pinocytosis

13 GERL system is formed of
(a) Golgi body, Endoplasmic Reticulum, Ribosome and Lysosome
(b) Golgi body, Endoplasmic Reticulum and Lysosome
(c) Golgi body, Endoplasmic Reticulum and Ribosome
(d) Golgi body, Ribosome and Lysosome

14 Which of the following is not a difference between euchromatin and heterochromatin?
(a) Heterochromatin stains deeply while euchromatin lightly
(b) Heterochromatin is more condensed than euchromatin
(c) Heterochromatin is transcriptionally inactive while euchromatin is active
(d) Heterochromatin lies close to the nucleolus while euchromatin to nucelar lamina

15 Identify *A*, *B*, *C* and *D* in the given figure.



(a) *A*–Nucleoplasm, *B*–Nucleolus, *C*–Nuclear pore, *D*–Nuclear membrane
(b) *A*–Nucleolus, *B*–Nucleoplasm, *C*–Nuclear membrane, *D*–Nuclear pore
(c) *A*–Nuclear pore, *B*–Nuclear membrane, *C*–Nucleoplasm, *D*–Nucleolus
(d) *A*–Nucleolus, *B*–Nucleoplasm, *C*–Nuclear pore, *D*–Nuclear membrane

16 In the view of current status of our knowledge about the cell structure, which of the following statements about cell theory is correct?
(a) The cell theory needed modification due to the discovery of subcellular structures such as chloroplasts and mitochondria
(b) The cell theory does not hold good, since all living organisms are not cellular in their organisation, e.g. virus
(c) The cell theory in its modified form, means that all living objects are made of cells capable of reproducing
(d) The cell theory means that all living objects of cell, whether or not capable of reproducing

17 Which of the following correctly explains mitochondrial function and results?
(a) Oxidative phosphorylation, dephosphorylation, metabolic water production
(b) Dephosphorylation, metabolic water production, CO_2 production
(c) Oxidative phsophorylation, metabolic water production, CO_2 production
(d) Oxidative phosphorylation, dephosphorylation, CO_2 production

18 In prokaryotes, chromatophores are
(a) specialised granules responsible for colouration of cells
(b) structures responsible for organising the shape of the organism
(c) inclusion bodies lying free inside the cells for carrying out various metabolic activities
(d) internal membrane systems that may become extensive and complex in photosynthetic bacteria

19 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?
(a) Proteins in cell membranes can travel within the lipid bilayer
(b) Proteins can remain confined within certain domain of the membrane
(c) Proteins can also undergo flip-flop movements in the lipid bilayer
(d) Many proteins remain completely embedded within the lipid bilayer

20 Match the following columns.

	Column I		Column II
A.	Endoplasmic reticulum	1.	Stack of cisternae
B.	Spherosome	2.	Store oils or fats
C.	Dictyosome	3.	Synthesis and storage of lipids
D.	Peroxisome	4.	Photorespiration
E.	Elaioplasts	5.	Detoxification of drugs

Codes

	A	B	C	D	E
(a)	5	3	1	4	2
(b)	5	3	2	4	1
(c)	2	3	1	4	5
(d)	4	3	1	5	2

ANSWERS

SESSION 1

1 (c)	**2** (c)	**3** (d)	**4** (a)	**5** (a)	**6** (b)	**7** (d)	**8** (d)	**9** (b)	**10** (b)
11 (c)	**12** (d)	**13** (d)	**14** (c)	**15** (b)	**16** (c)	**17** (a)	**18** (b)	**19** (b)	**20** (c)
21 (b)	**22** (a)	**23** (b)	**24** (b)	**25** (c)	**26** (a)	**27** (a)	**28** (c)	**29** (a)	**30** (b)
31 (a)	**32** (b)	**33** (c)	**34** (b)	**35** (a)	**36** (a)	**37** (a)	**38** (a)	**39** (b)	**40** (b)
41 (b)	**42** (d)	**43** (c)	**44** (d)	**45** (a)	**46** (a)	**47** (a)			

SESSION 2

1 (b)	**2** (a)	**3** (d)	**4** (a)	**5** (d)	**6** (c)	**7** (a)	**8** (d)	**9** (b)	**10** (a)
11 (b)	**12** (d)	**13** (b)	**14** (d)	**15** (a)	**16** (c)	**17** (c)	**18** (d)	**19** (c)	**20** (a)