SEMESTER–V

DESCIPLINE SPECIFIC COURSE IN BOTANY-DSCB (A Theory Course)

DSCB-I: Cell and Molecular Biology **(Theory Paper-XII)**

DESCIPLINE ELECTIVE COURSE IN BOTANY-DECB (A Theory Course)

DECB-I: Plant Pathology-I **(Theory Paper-XIII)**

OR

DECB-I: Systematic Botany-I **(Theory Paper-XIII)**

OR

DECB-I: Herbal Technology-I **(Theory Paper-XIII)**

Peri

Credits: 02 (Maximum Mar

SEMESTER–V

DSCB-I: CELL AND MOLECULAR BIOLOGY

(Theory Paper-XII)

Learning Objectives:

1. To know about the ultra structure of a cell, cell wall, cell membrane, cell organelles and chromosomes, cell cycle and cell division.
2. To study in detail the structure of DNA and RNA, protein synthesis, gene structure, gene mutation and related diseases.
3. To acquire knowledge of cell and molecular biology

Learning Outcomes:

1. The students will be able to understand ultra structure of a cell, cell wall, cell membrane, cell organells and chromosomes, cell cycle and cell division.
2. The students will be able to understand in detail the structure of DNA and RNA, protein synthesis, gene structure, gene mutation and related diseases.
3. Students will acquire knowledge of cell and molecular biology

UNIT-I: CELL BIOLOGY-I (11 Periods)

1. Cell: the unit of life, ultra structure of Prokaryotic and eukaryotic cells, 2. Ultra structure and functions of cell wall and cell membranes (Fluid Mosaic Model), 3. Ultra Structure and functions of cell organelles: Golgi apparatus, Endoplasmic reticulum, Ribosomes, Lysosomes, Peroxisomes, Glyoxisomes and Nucleus.

UNIT-II: CELL BIOLOGY-II (12 Periods)

1. Chromosome: Morphology, structure and function of typical chromosome and Karyotype and Idiogram, 2. Structure and significance of giant Chromosomes: Polytene chromosome and Lampbrush chromosome, 3. Cell cycle: G0 - G1 - S - G2 phase, Cell division: Process and significance of Mitosis and Meiosis.

UNIT-III: MOLECULAR BIOLOGY-I (11 Periods)

1. Nucleic Acids- Introduction, Chemical composition, Structure of DNA (Watson and Crick model), Replication of DNA Meselson and Stahl expt.), Structure, function and types of RNA. 2. Protein synthesis: Genetic code (Nature and Properties), Transcription, Translation.

UNIT-IV: MOLECULAR BIOLOGY-II (11 Periods)

1. Classical concept of gene (theory of Morgan), Fine structure of gene (Seymour Benzer's), Regulation of gene expression in prokaryotes (Lac Operon Model) 2. Molecular Basis of Gene Mutation and related diseases: Phenylketonuria (PKU), Alkaptonuria (AKU), Albinism and Amniocentesis (Detection of genetic diseases).

Theory Paper-XII: Cell and Molecular Biology

(Unit Wise Distribution of Periods and maximum marks)

Unit	Title of the unit	Periods Distributed	Maximum Marks
Unit-I	Cell biology-I	11	20
Unit-II	Cell biology-II	12	20
Unit-III	Molecular biology-I	11	20
Unit-IV	Molecular biology-II	11	20
Total		**45**	**80**

SEMESTER–V

DECB-I: PLANT PATHOLOGY-I

(Theory Paper-XIII)

Learning Objectives:

1. To know about the fundamentals of plant pathology.
2. To study in detail the process of plant disease development.
3. To acquire knowledge of different plant diseases in different plants.

Learning Outcomes:

1. The students will be able to understand fundamentals of plant pathology.
2. The students will be able to understand in detail the process of plant disease development.
3. Students will acquire knowledge of different plant diseases in different plants.

UNIT-I: FUNDAMENTALS OF PLANT PATHOLOGY (11 periods)

Scope, importance, history and advancement of plant pathology, classification of plant diseases on the basis of causal organism and symptoms, field and laboratory diagnosis-Isolation of plant pathogens from infected plant parts, soil and air, pure culture techniques, Koch's postulates for pathogenicity.

UNIT-II: PLANT DISEASE DEVELOPMENT (11 periods)

Disease development- Mode of entry of pathogens (through stomata, wounds, root hairs and buds), Factors affecting disease development-Temperature, moisture, wind and soil pH, Dispersal of plant pathogens (by air, water, insects and animals), chemical weapons of pathogen: enzymes, toxins and growth regulators.

UNIT-III: PLANT DISEASES-I (12 periods)

Symptoms, causal organisms, disease cycle and control measures of Green ear of Bajra, early blight of tomato, Grain smut of Jowar, Red rot of Sugarcane, Angular leaf spot of cotton, Bacterial blight of Pomegranate, Anthracnose of mango

UNIT-IV: PLANT DISEASES-II (11 periods)

Symptoms, causal organisms, disease cycle and control measures of White rust of Mustard, Whip smut of Sugarcane, Powdery mildew of pea, Leaf spot of Turmeric (*Colletotrichum capsci*), Citrus canker, Sigatoka disease of Banana, leaf blight of Rice.

Unit-I: Cell Biology-I

(*) Introduction to cell biology (Cytology):—

'Cell Biology' is the study of structure and functions of the cells. It is also called 'Cytology'. The Cell theory was proposed by Schleiden (1838) & Schwann (1839). According to the Cell theory the bodies of plants and animals are made up of cells, and each cell can act independently. The cell contains nucleus, which controls the activities of the cell. There are some objections to cell theory. (a) Certain organisms are not made up of cells. (eg:- Viruses). (b) Certain organisms do not possess true nucleus. (eg:- Bacteria, blue-green algae), etc.)

(*) Cell:—

In 1665, Robert Hook discovered cells. While examining a thin slice of cork under his crude microscope Hook observed the small chambers surrounded by walls. He called these chambers as 'Cells'.

"A cell is the structural and functional unit of an organism." It is a basic unit of structure or organization of all living organisms. The cells are building blocks of organisms.

There are two types of cells —

(1) Prokaryotic cells & (2) Eukaryotic cells.

(1) Prokaryotic cells:— (Pro - primitive, karyon - nucleus)

The prokaryotic cells contain primitive nucleus. ie. nucleus without nuclear membrane. Such type of nucleus without nuclear membrane is called as nucleoid. eg:- Bacteria, blue-green algae, etc.

(2) Eukaryotic cells:— (Eu - true, karyon - nucleus)

The eukaryotic cells contain true or definite nucleus. ie. the nucleus with nuclear membrane. eg:- Plants (algae to angiosperms) and animals (protozoa to mammals)

(*) Differences in prokaryotic & eukaryotic cells:

Characters	Prokaryotic cell	Eukaryotic cell
(1) Size of cell	Small (1 – 10 μ)	Large (10 – 100 μ)
(2) Cell-wall	present & made up of peptidoglycan.	Present in plant cells & made up of cellulose.
(3) Nucleus	Primitive (lacks nuclear membrane)	True (possesses nuclear membrane)
(4) Chromosome	Circular, only one, no histone-proteins	Thread-like, more than one, ~~conta~~ associated with histone-proteins.
(5) Cell-organelles (Internal membrane)	Absent	Mitochondria, chloroplaste, golgi complex, lysosomes present.
(6) Flagella	9+2 fibrillar pattern absent	9+2 fibrillar pattern present

⊛ Ultrastructure of prokaryotic cell :-

(Ultrastructure of bacterial cell) :-

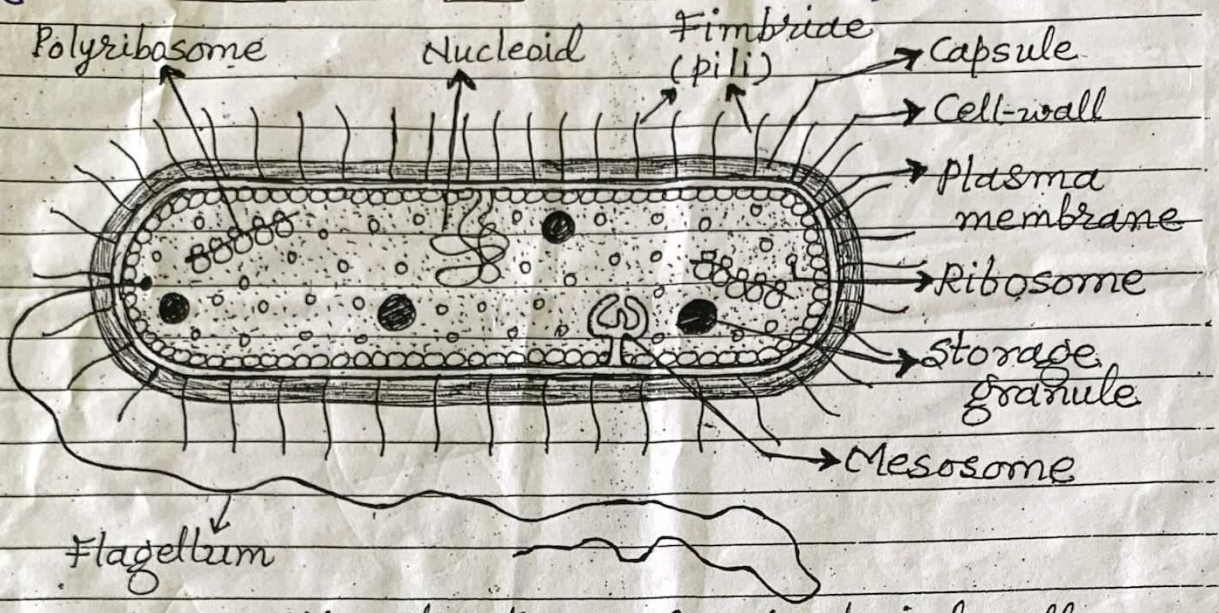

Fig.: Ultrastructure of a bacterial cell.

Ultrastructure of a bacterial cell shows the following structures :-

1) Flagella :- These are thin, elongated, thread-like structures, which help in locomotion. The bacterial flagellum is made up of protein "flagellin". It is developed from a basal granule, called as "blepharoplast".

2) Pili (Fimbriae) : These are the superficial appendages, which are much smaller than flagella. They are many in number. They are made up of protein "pilin". Pili help in attachment of bacteria during conjugation. They also help in attachment of bacteria to host.

3) Capsule :- In some bacteria, cell-wall is surrounded by a gelatinous covering, called as capsule. It is polysaccharide of glucose. Capsule protects the bacteria from phagocytosis & viruses.

4) Cell-wall :- The cell-wall is strong and rigid. It is made up of peptidoglycan or mucopeptide. It is a polymer made up of N-Acetyl glucosamine (NAGA) & N-acetyl muramic acid (NAMA), joined by β-1,4-linkage. The cell wall gives shape to the bacterial cell.

5) Plasma membrane :- The bacterial protoplast is bounded by a thin plasma membrane. It is made up of lipoproteins (lipids & proteins). The plasma membrane provides site for the attachment of the bacterial chromosome (nucleoid). Certain proteins of the plasma membrane act as enzymes in respiration.

6) Mesosomes :- It is the extensions of the plasma membrane. It initiates DNA replication & septum formation during cell-division.

7) Ribosomes :- Ribosomes are small, granular particles present in the cytoplasm. In bacteria, the ribosomes lie freely in the cytoplasm. But, in eukaryotes, they lie attached to endoplasmic reticulum. Ribosomes help in protein synthesis. 70 stype

8) Storage granules :- Reserved food-materials are stored in the form of granules called storage granules. There are 3 types of reserved food-materials, viz.: Poly-β-hydroxybutyric acid, Volutin & Sulphur. Sulphur occurs only in few bacteria.

9) Nucleoid :- In bacteria, the genetic material consists of a circular, double-stranded DNA molecule. It do not have nuclear membrane & is called nucleoid. It is attached to plasma membrane.

10) Plasmid :- Many species of bacteria have extra-chromosomal DNA molecule, called plasmid. Some plasmids produce proteins, which inhibit the growth of other bacteria. Some plasmids are helpful in conjugation. Some plasmids give resistance against many drugs.

—x—

⊛ Ultrastructure of Eukaryotic cell (Plant cell)

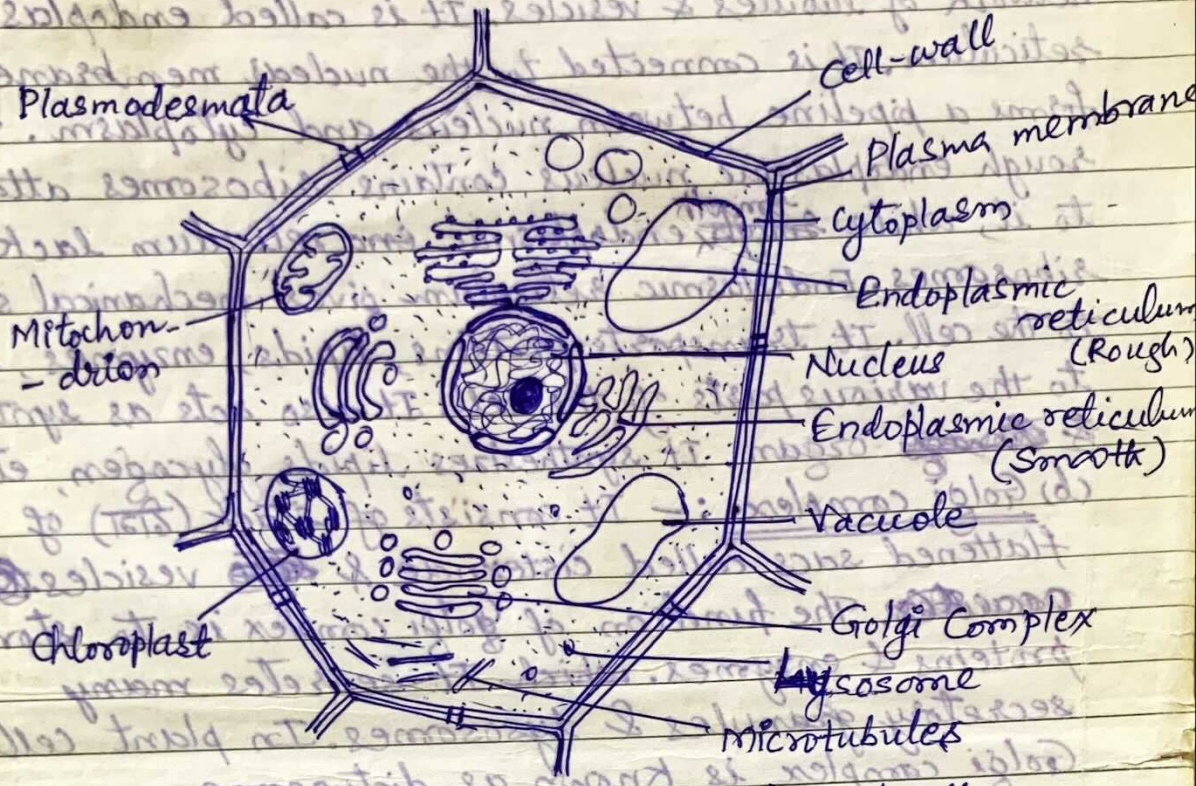

Fig.: Ultrastructure of a typical plant cell

An eukaryotic cell consists of following components :—

① **Cell-wall** :- The ~~protoplasm of~~ plant cells is covered by a rigid cell-wall. It is made up of a complex polysaccharide 'cellulose'. The cell-wall protects the plasma membrane & cytoplasm. The cell-wall of some plant cells has some pit-like structures called plasmodesmata. Cell-wall is absent in animal cells.

② **Plasma membrane** :- In Both plant and animal cells, ~~have external covering known as~~ the protoplast is bound by a thin & delicate membrane called plasma membrane. In plant cells, it occurs below cell-wall. It is made up of lipoproteins i.e. Outer & inner layers of proteins & middle layer of lipids. The plasma membrane is selectively permeable. It provides mechanical support to protoplasm and checks the entry or exit of undesirable substances thro' it

③ Cytoplasm :- Within the plasma membrane, there is cytoplasm, which consists of following structures :-

(a) Endoplasmic reticulum :- It is a network of membrane-bound tubules & vesicles. It is of two types: The smooth endoplasmic reticulum lacks ribosomes, while rough endoplasmic reticulum contains ribosomes attached to it. The endoplasmic reticulum gives mechanical support to the cell. It transports proteins, lipids, enzymes, etc. to various parts of cell. It also synthesises lipids, cholesterols, etc.

(b) Golgi Complex :- It consists of stack (ढेर) of flattened sacs called cisternae and vesicles. The function of Golgi complex is to secrete polysaccharides, form plasma membrane, etc. Lysosomes are produced from the Golgi Complex. Golgi Complex in plants is called as dictyosome.

(c) Lysosomes :- These are spherical or irregular-shaped membrane-bound vesicles. They are originated from Golgi complex & contain many digestive enzymes. Lysosomes help in digestion of food-material which comes in the cell by phagocytosis or pinocytosis. The lysosomes in plant cells are membrane-bound granules. The lysosomes are called as suicide bags; because they help in autolysis of cells.

(d) Vacuoles :- Vacuoles are hollow, liquid-filled-structures. They store water, phenols, alkaloids, etc.

(e) Ribosomes :- Ribosomes are small, spherical structures. They are either attached to endoplasmic reticulum or lie freely in cytoplasm. They are made up of RNA and proteins. Ribosomes are site of protein-synthesis in the cells.

80 S Type

(f) Mitochondria :- Mitochondria are large, rod-like structures. They are bound by two membranes. The outer membrane is smooth, while inner produces many finger-like outgrowths, called cristae. Mitochondria perform respiration. They are called "power house" of the cell.

(g) Plastids :- Plastids are present only in plant cells. These are large & may be colorless or colored. The colorless plastids are called leucoplastids & colored plastids are called chromoplastids. The leucoplastids / leucoplasts have storage function & store stareh (amyloplasts) or lipids (lipoplasts). The chromoplasts have various pigments. The chromoplasts having chlorophyll-pigment are called chloroplasts. They perform photosynthesis.

(h) Microtubules :- These are ultrafine Tubules, which are made up of protein "tubulin". They transport water ions or small molecules & form asters or fibres during cell divisi They are structural units of cilia & flagella.

(4) Nucleus :-

The nucleus is a centrally located spherical structures. It controls all activities of the cell. It consists of following three parts :-

(i) Nuclear membrane :- The nucleus is bound by a double-layered nuclear membrane. It has small pores in it. Nuclear membrane regulates the flow of material between cytoplasm and nucleoplasm.

(ii) Nucleoplasm & chromosomes :- The space between nuclear membrane and nucleolus is filled by a watery substance called nucleoplasm. It contains phosphorous, ribose sugars, proteins & also thread-like, elongated structures called chromosomes. They appear only during cell-division. The chromosomes are granules called

The chromosomes occur as granules called chromatin granules. The chromatin granules or chromosomes contain DNA & pr

(iii) Nucleolus :- The nucleoplasm contains a spherica structure called nucleolus. It is made up of ribosomal RNA & proteins. The nucleolus stores rRNA molecule synthesized by DNA & provides raw materials such rRNA & proteins for synthesis of ribosomes.

Study of Cell organelles

Endoplasmic Reticulum :-

(A) Ultrastructure of ER :-

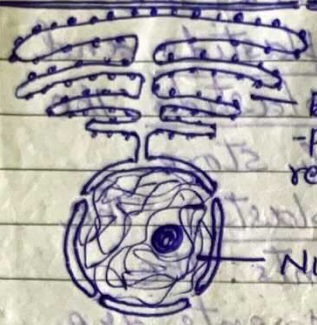

Fig: Structure of endoplasmic reticulum

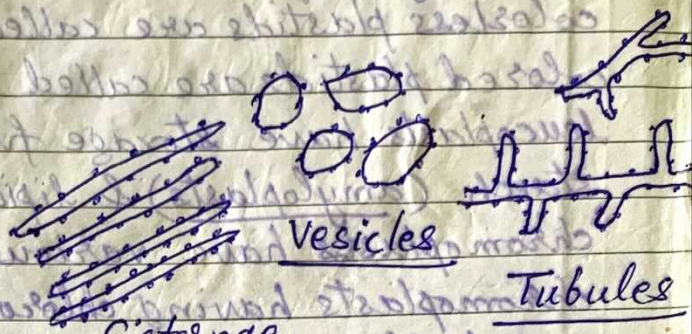

Fig: Components of Endo. Reti.

Endoplasmic reticulum is a network of membrane bound tubules and vesicles, distributed throughout the cytoplasm. The term endoplasmic reticulum was introduced by Porter (1953), who observed it in liver cells.

Endoplasmic reticulum is made up of three components, viz:- Cisternae, vesicles and tubules.

(a) Cisternae :- These are long, flat, unbranched structures. They are arranged in stacks / parallel bundles.

(b) Vesicles :- These are oval structures.

(c) Tubules :- These are branched tubular structures.

There are two types of ER — (i) Agranular or smooth ER and (ii) Granular or rough ER.

(i) Agranular or Smooth ER :- This type of ER possess smooth walls, because ribosomes are not attached it. The smooth ER occurs in cells, which have no active participation in protein synthesis. It is well-developed in cells that synthesize steroid hormone lipids. It is found in adipose cells, interstitial cells, etc.

(ii) Granular or Rough ER :— This type of ER possesses rough walls, because ribosomes are attached to it. Ribosomes play a vital role in the process of protein synthesis. The rough ER is found abundantly in those cells which are active in protein synthesis, such as pancreatic cells, plasma cells, etc.

Annulate lamellae :— Usually ER has no pores, or annuli in it, but in certain cases, pores ~~have~~ or annuli have been reported. eg :- ER of invertebrates, ovocytes & spermatocytes of vertebrates.

(B) Functions of endoplasmic reticulum :—

Common functions of SER & RER :-

(i) Mechanical support :- The endoplasmic reticulum provides a framework to the cell & gives mechanical support to the cytoplasmic-matrix.

(ii) Exchange of molecules :— The exchange of molecules by osmosis, diffusion & active transport occurs thro' the membranes of ER.

(iii) Circulation & transportation :- ER acts as circulatory and transporting system.

Functions of SER :-

(i) Synthesis of lipids — phospholipids, cholesterol, etc.
(ii) Glycogenolysis — Breakdown of glycogen.
(iii) Detoxification — Detoxification of liver. ie. harmful materials are converted into harmless substances suitable for excretion by the cell.

~~(iv)~~

Functions of RER :—

(i) The main function of RER is protein synthesis.
(ii) Glycosylation — The addition of carbohydrate to other cellular molecules. It leads to the formation of glycoproteins, glycolipids etc.

⊛ Golgi Complex :-

Golgi complex is a stack (ढेर) of flattened sacs called Cisternae and vesicles. It is also called as Golgi ~~It was~~ body or dictyosome.

The Golgi complex was discovered by Camillo Golgi (1898) in the nerve cells of owl and cat.

Ⓐ Ultrastructure of Golgi complex :-

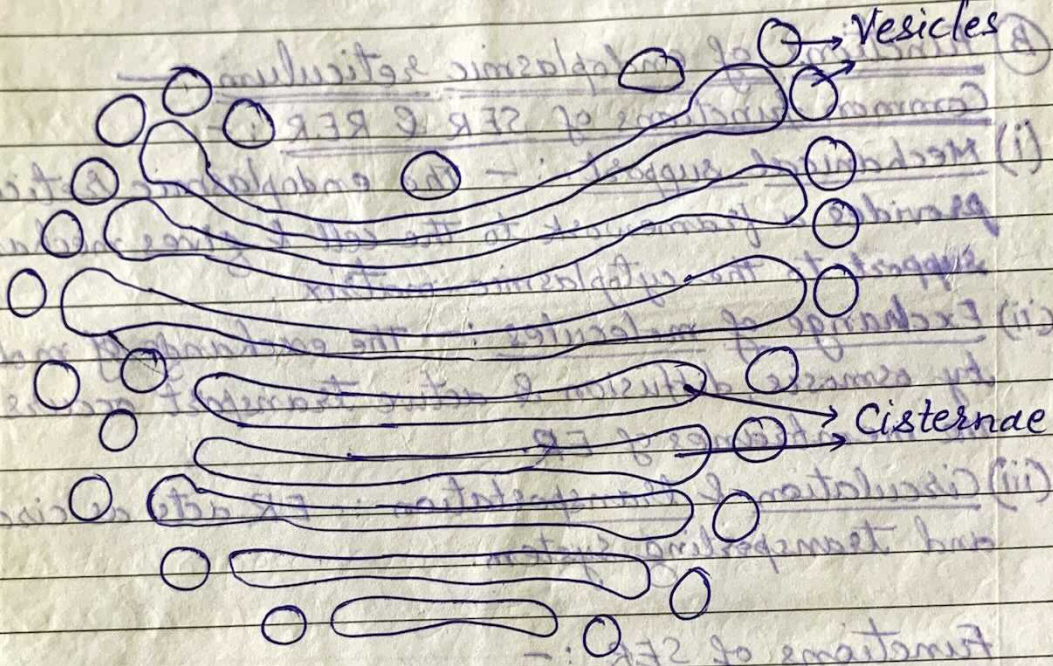

Fig. :- Golgi complex.

The Golgi complex consists of ~~three~~ four components :-

(a) Cisternae :- These are flattened sacs filled with fluids. They are arranged in parallel bundles or stack one ~~over~~ above the other. Cisternae are slightly curved, due to which the Golgi complex becomes concave or convex.

(b) Vesicles :- These are small, droplets-like-structures, which are associated with the periphery of the cisternae. They are developed from the cisternae.

(c) Tubules :- From the peripheral area of cisternae many small tubules arise & interconnect the cisternae & vesicles. ~~The~~

(d) Vacuoles :- The Golgian vacuoles are large, ~~spherical~~ rounded structures occuring at the edges of cisternae. They are developed from cisternae.

(B) Functions of Golgi complex :-

(i) Formation of lysosomes :- Golgi complex is involved in synthesis of lysosomes. The cisternae of Golgi complex gives rise to small vesicles called primary ~~vesicles~~ lysosomes, which fuse with phagosomes or pinosomes to form secondary lysosomes.

(ii) Synthesis of polysaccharides :- Polysaccharides are synthesized in the Golgi complex.

(iii) Plasma-membrane formation :- Golgi complex plays an important role in ~~synthesis~~ formation of plasma membrane.

(iv) Plant cell-wall formation :- The cell-wall of plants is made up of polysaccharides. The pectin & ~~some~~ other mucilaginous substances of plant cell-wall are synthesized in Golgi complex.

(v) Sulphation :- Golgi complex takes part in sulphate metabolism. The compounds containing active sulphur are formed in Golgi complex.

(vi) Acrosome formation :- The acrosome vesicle lies in front of the nucleus in sperm. Golgi complex plays important role in acrosome formation.

⊛ Lysosomes :-

(Lyso ÷ Digestive, some ÷ body)

The lysosomes are spherical or irregular-shaped membrane-bound vesicles. They contain digestive enzymes, which are capable of breaking down a variety of materials. Lysosomes were first reported by de Duve in 1955. The lysosomes usually occur in most animal cells & some plant cells. Lysosomes are also called "Suicide bags."

⊛ Ultrastructure ~~and functions~~ of lysosomes :-

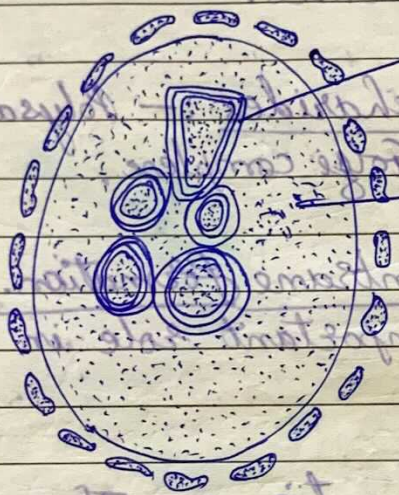

Fig: Lysosome in the kidney cell of rat.

The lysosomes are spherical or irregular-shaped. Their size ranges from 0.2 – 0.8 μm. They are bound by a single-layered membrane, made up of lipoproteins. Within the membrane, there are large number of dense granules having hydrolytic enzymes.

The lysosomes contain about 40 different type of enzymes or hydrolases. The enzymes are of six main types, as follows :-

(a) Nucleases :- They act on nucleic acids & break them in to nucleotides.

(b) Phosphatases :- They act on phosphate compounds.

(c) Sulphatases :- They break down sulphate esters into fragments.

(d) Lipases :- They act on lipids & break them into fragments.

(e) Proteases :- They break down proteins in to amino acids.

(f) Glycosidases :- They break down polysaccharides into monosaccharides.

Polymorphism in lysosomes :-

The lysosomes show polymorphism in different cell-types & even within a single cell. They are as follows:-

(i) Primary lysosome (storage granule) :- It is formed directly from the endoplasmic reticulum or indirectly from Golgi complex by budding.

(ii) Secondary lysosome :- The phagosome is formed by phagocytosis or pinocytosis of foreign material. The phagosome associates with primary lysosome & fuses to form secondary lysosome.

(iii) Residual body :- It is the final particle containing indigestible material. In protozoa, these bodies are removed from the cell. But, in animal cells, they get accumulated.

(iv) Autophagic vacuole :- It is a lysosome containing some part of the cell in the process of digestion. Cell organelles like mitochondria, endoplasmic reticulum, etc. may be found in autophagic vacuole.

(B) Functions of lysosomes :-

(i) Digestion of large extracellular particles :- The lysosomes digest the food-content of phagosomes or pinosomes.

(ii) Digestion of intracellular substances :- During the starvation, lysosomes digest the stored food-content of cytoplasm like proteins, lipids & carbohydrates & provide energy to the cell.

(iii) Autolysis :- In certain pathological conditions, lysosomes digest various organelles of the cell. This is called autolysis / autophagy.

(iv) Extracellular digestion :- It is the digestion of materia outside the cell. In certain occasions, lysosomes release the enzymes outside the cell & bring about digestion. During fertilization, acrosome of sperm releases lytic enzymes on the egg-membrane. The enzymes dissolve egg membrane & thus penetration of sperm becomes easy.

Lysosomes in plant cell :-

Lysosomes are absent in plant cells. However, plant cells contain membrane-bound granules. They are sphaerosomes (maize root tips), aleurone grains (cotyledons & endosperm of seeds) and vacuoles (store oils, alkaloids, etc.)

Extracellular digestion by plants :-

Plant cells are generally unable to engulf large particles because of cell wall. The hydrolases are secreted by fungi. Higher plants also secrete hydrolases. The notable example is insectivorous pitcher plants, which produce a proteinase-containing liquid in which victims are trapped & digested.

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⊛ Ribosomes :-

The ribosomes are small, rounded and granular particles present in cytoplasm. They occur either freely or remain attached to endoplasmic reticulum. The ribosomes were first noted in plant cells by Robinson & Brown (1953). In animal cells, ribosomes were firstly observed by Palade (1955).

In prokaryotic cells, they occur freely in cytoplasm, while in eukaryotic cells, ribosomes are attached to endoplasmic reticulum.

Types of ribosomes :-

The ribosomes are of two basic types - 70S and 80S. The 's' refers to "Svedberg unit." This is a sedimentation coefficient, which shows how fast the organelles sediments in an ultracentrifuge. Heavy structure has more sedi. coeff.

70S ribosomes are found in prokaryotes (eg. bacteria). The 70S ribosome consists of a large 50S subunit & a small 30S subunit.

80S ribosomes are found in eukaryotes (eg. algae, fungi, higher plants and animals). They consist of a large 60S sub-unit & a small 40S sub-unit.

(A) Ultrastructure of ribosomes :-

The ribosomes are oblate spheroid structures, having a diameter of 150 - 250 A°. Each ribosome is composed of two sub-units. One ribosomal sub-unit is larger in size & has a dome-like shape, while other sub-unit is smaller in size and occurs as ring above the large sub-unit & forms a cap-like structure.

Ribosome of prokaryotes

Ribosome of eukaryotes

The 70S ribosome consists of two sub-units, viz.: 50S and 30S. The 50S sub-unit is larger, while 30S sub-unit is smaller in size. The 80S ribosome consists of two sub-units, viz.: 60S and 40S. The 60S sub-unit is larger, while 40S sub-unit is smaller in size. The two sub-units are united with each-other due to high conc. of Mg^{++} ions. When the concentration of Mg^{++} ion reduces in the cytoplasm, the ribosomal sub-units get separated. In bacterial cell, the two sub-units occur freely in cytoplasm & unite only during protein synthesis. At high concentration of Mg^{++} ions, the two ribosomal units combine to form a 'dimer'. During protein synthesis, ribosomes are aggregated to common mRNA to form polyribosom

Chemical composition :—

The ribosomes are chemically composed of RNA & proteins & enzymes. The 70S ribosome contains more RNA & less proteins, while 80S ribosome contains less RNA & more proteins.

(a) Ribosomal RNA :- The 70S ribosome contains three types of rRNA, viz.: 23S rRNA, 16S rRNA, 5S rRNA. The 23S & 5S rRNA occur in 50S sub-unit, while 16S occurs in 30S sub-unit.

The 80S ribosome contains four types of rRNA, viz.: 28S rRNA, 18S rRNA, 5S rRNA & 5.8S rRNA. The 28S, 5S and 5.5S rRNA occur in 60S sub-unit, while 18S rRNA occur occurs in 40S sub-unit.

(b) Ribosomal proteins :— The 70S ribosome contains about 55 proteins → 21 in 30S sub-unit, & 32-34 proteins in 50S sub-unit of ribosome. The 80S ribosome contains 80 proteins → 30 in 40S sub-unit & 50 proteins in 60S subunit.

(c) Enzymes (protein factors) :— The ribosomal enzymes include initiation factors, elongation factors & termination factors

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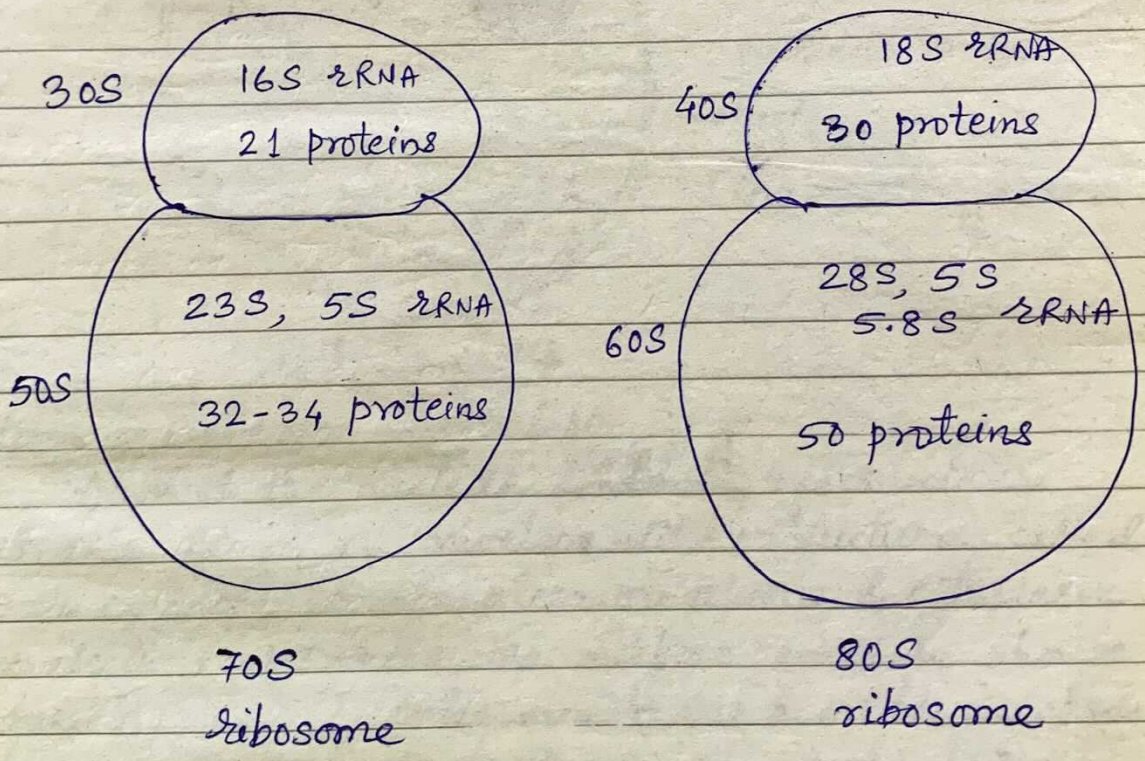
(B) Functions of ribosomes :—

(1) **Protein-synthesis** :- Ribosomes play important role in protein-synthesis. Two or more ribosomes on same mRNA strand are called polyribosomes. The ribosome brings together ~~the~~ different components involved in protein-synthesis.

(2) **Protection** :- The mRNA strand which passes between the two ~~&~~ sub-units of ribosome is protected from the action of enzymes. Similarly, the newly formed polypeptide chain is also protected from enzymes.



⊛ Nucleus :-

The nucleus is the heart of the cell. It controls all the activities of the cell. It is also called brain of the cell. The nucleus was discovered by Robert Brown (1831).

The nucleus is composed of following structures :-
(i) Nuclear (Envelope) membrane, (ii) Nucleolus
(iii) Nucleoplasm, and (iv) Chromatin fibres.

~~(i) Nuclear membrane~~ :-

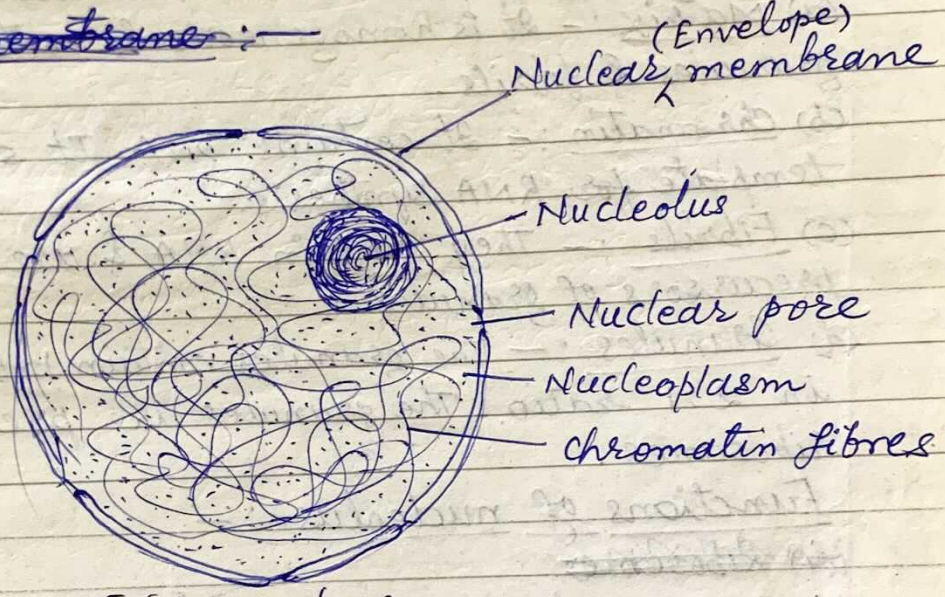


Fig. :- Nucleus

(i) Nuclear membrane / Envelope :-

Around the nuclear ~~contents~~ material, the nuclear membrane forms an envelope-like-structure, called nuclear envelope. It separates nucleoplasm & cytoplasm. Under electron microscope, the nuclear envelope shows two membranes; viz: Outer membrane & inner membrane. They are made up of lipoproteins. The space between outer & inner membrane is called perinuclear space. (The outer membrane sometimes remains continuous with endoplasmic reticulum, Golgi Complex, etc. The inner membrane remains associated with chromatin fibres).

The nuclear membranes are not continuous, but at some places, show some pores or openings called nuclear pores. Around the margins of these pores, both nuclear membranes are in continuity. The

nuclear pores may be circular or octagonal in structure.

Functions of nuclear envelope :- The nuclear envelope allows free exchange of ions and molecules between nucleus and cytoplasm.

(ii) Nucleolus :-

The nucleus contains a large, spherical structure, called nucleolus. It was first described by Fontana (1781).

The nucleolus contain consists of 4 components:

(a) Matrix :- It is homogeneous & contains scattered granules & fibrils.

(b) Chromatin :- It contains DNA. It serves as a template for RNA synthesis.

(c) Fibrils :- They contain RNA & are probably the precursors of granules.

(d) Granules :- The granules contain protein & RNA in 2:1 ratio. The granules are precursors of ribosomes.

Functions of nucleolus :-

~~(a) Ribosome~~

(i) RNA production :- The nucleolus is the most active site of RNA synthesis. It produces 70-90 % of cellular RNA. It is the source of rRNA.

Chromatin (DNA) → Fibrils (RNA) → Granules (RNA) → Ribosomes

(ii) Protein synthesis :- Ribosomal proteins are synthesized in the nucleolus.

(iii) Ribosome formation :- Nucleolus plays important role in ribosome formation, because it synthesizes rRNA & proteins.

(iii) Nucleoplasm :-

The space between nuclear envelope and nucleolus is filled by a matrix called nucleoplasm. It contains chromatin threads, nucleoprotein granule nucleolus, etc. suspended in it.

(iv) Chromatin fibres :-

The nucleoplasm contains many thread-like, elongated structures called chromatin fibres. Such fibres are observed in interphase nucleus. During cell-division (mitosis & meiosis), the chromatin fibres become thick & called as chromosomes.

Functions of Chromosomes :-

1) The chromosomes carry genetic information from one generation to other generation.
2) They control all the activities of the cell.

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* Cell wall :-

In plants, a cell is always surrounded by cell wall. This feature distinguishes plant cell from animal cell. In most of the plant cells, cell wall is made up of cellulose, hemicellulose and compounds of pectic acid. In fungi, cell wall is made up of chitin. In bacteria, the cell wall contains protein - lipid - polysaccharide complexes.

Structure of cell wall :-

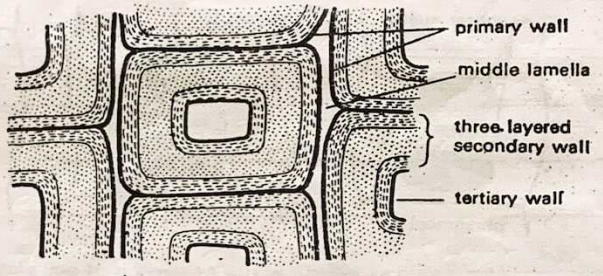

Fig. 2-1. A few cells showing gross structure of cell wall (redrawn from Frey-Wyssling and Muhlethaler : *Ultrastructural Plant Cytology*).

The cell wall is complex in nature and is differentiated into following three layers -

i) **Primary cell wall** :- The first formed layer is called primary wall. It is outermost thin layer. It is permeable. Certain epidermal cells of leaf & stem also possess cutin & cutin waxes, which make the primary wall impermeable.

ii) **Secondary wall** :- Within the primary wall, there is secondary wall. It is thick and made up of 3 layers (S_1, S_2 and S_3). Secondary wall is composed of compactly arranged microfibrils of cellulose and lignin in between them.

iii) **Tertiary wall** :- Beneath secondary wall, there is tertiary wall. Along with cellulose, it consists of another chemical substance called xylan.

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Middle lamella :- The cells of plant tissues generally remain cemented together by an intercellular matrix known as middle lamella. It is composed of pectin, lignin and some proteins.

Ultrastructure of cell wall :-

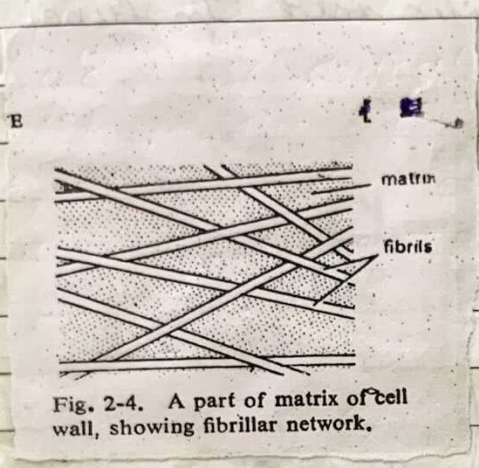
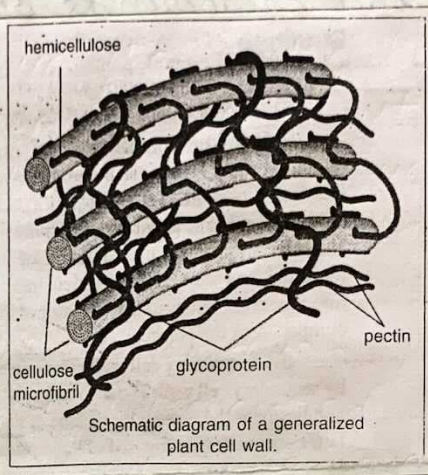


Fig. 2-4. A part of matrix of cell wall, showing fibrillar network.



Schematic diagram of a generalized plant cell wall.

Under electron microscope, the cell wall shows two main parts - fibrils and matrix. The fibrils (microfibrils) consist of cellulose and rarely of chitin. They are flat, being 10 nm wide & 3 nm thick ($1\,nm = 10\,A^{\circ} = 10^{-6}\,mm$). Relative amount of these fibrils & matrix varies. In cell plate, cellulose microfibrils are absent, while in cotton ~~fibres~~ hairs, 95 % cellulose is present. Also the orientation of these fibrils in cell wall with respect to the axis of the cell varies. These may be parallel to the cell axis, oblique, perpendicular or may be randomly distributed.

Functions of cell wall :-

1) The main function of cell wall is that, it provides mechanical strength to the cell. Cell wall acts like a skeletal framework of plants.

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2) The cell wall protects the plant cell & maintains its shape. It holds the cell content intact.
3) It ensures transportation of molecules across the cell.

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★ Cell membrane / Plasma membrane / Plasmalemma :-

All type of cells contain an ultrathin, elastic, selectively permeable membrane called cell membrane / plasma membrane / plasmalemma. This is the living outer boundary of all cells, but plant cells have cell wall outside the plasma membrane.

The term cell membrane was coined by C. Nageli & C. Cramer (1855) & term plasmalemma has been given by J. Q. Plower (1931).

Chemical composition :-

The plasma membrane includes ~~proteins~~ lipids, proteins, small proportion (1-5%) of oligosaccha-rides & water (20% of total weight). Therefore, the main constituents of plasma membrane are lipids & proteins.

(1) **Lipids** :- Lipids form 25-80% of the mass of the cell membrane. The main lipid components are phospholipids, cholesterol, & galactolipids. ~~There~~ Their relative proportion varies in different cell membranes.

A lipid molecule consists of two parts — a head (glycerol) which is hydrophilic (water soluble) and Two tails (fatty acids) which are

hydrophobic (water insoluble). The lipid molecules make a bilayer with tails oriented inwards & perpendicular to the surface of the membrane. The external surface of the bilayer consists of heads & provide surface for deposition of protein.

(2) Proteins :— Proteins represent a major component of all biological membranes. They provide a mechanical structure & also help in transportation of material in and out of the cell or an organelle. Besides the structural proteins, there are other proteins, which act as enzymes.

With respect to their organization, proteins may be extrinsic/peripheral (associated with membrane surface & can be easily removed) and intrinsic/integral (enter in the lipid bilayer & can not be easily removed).

Ultrastructure of cell membrane :—

Fluid Mosaic Model :—

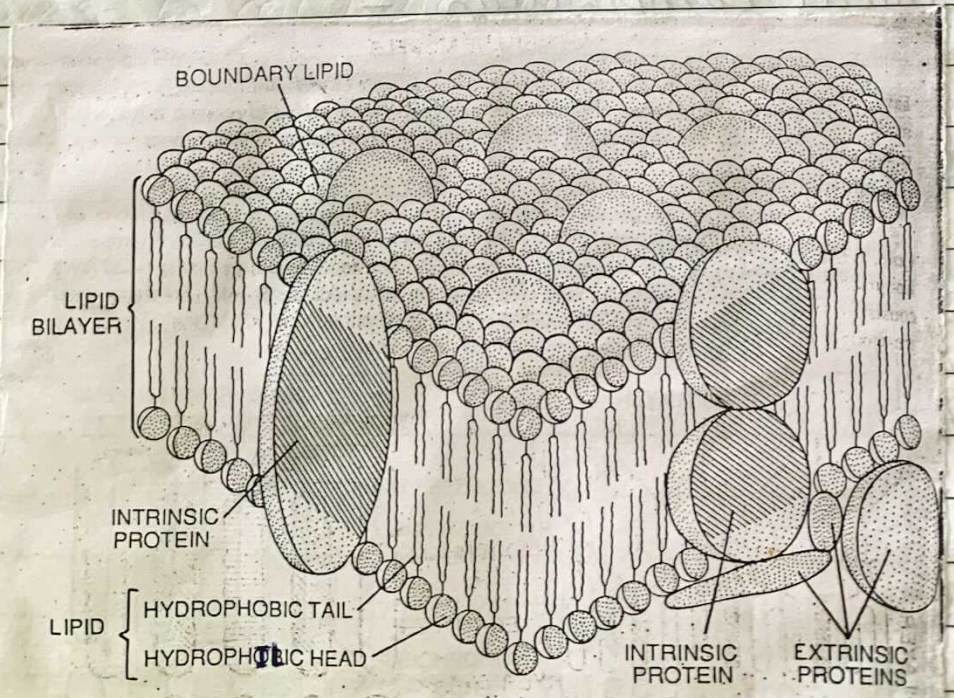

Fig. 33.11. The fluid mosaic model of plasma membrane

Fluid mosaic model is widely accepted model of biological membranes. It was suggested by S. J. Singer & G. L. Nicolson (1972).

According to this model, the plasma membrane contains a ~~bimolecular~~ lipidbilayer. Both surfaces are interrupted by protein molecules. The lipids and proteins are present in mosaic arrangement. Some proteins are attached at the polar surface of the lipid (extrinsic proteins), while others either partially or fully penetrate the bilayer (intrinsic proteins).

~~In~~ The lipid and intrinsic proteins are present in mosaic pattern. The membranes are semifluid, sothat the lipids and intrinsic proteins are able to make movements within the bilayer. On account of its fluidity & the mosaic arrangement of protein molecules, this model of membrane structure is called 'fluid mosaic model'.

Functions of plasma membrane :—

1) Permeability :- Plasma membrane allows movement of ions & molecules through it. This nature of plasma membrane is called permeability. It is semipermeable / selectively permeable.
2) Useful nutrients are selectively allowed entrance, while waste materials are selectively allowed to leave.
3) The plasma membrane is vital for the maintenance of a stable, steady internal environment because of its semipermeable nature.
4) This simply means that, the membrane controls what can enter or exit the cell.

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: Microbodies :

Glyoxysomes & Peroxisomes

Microbodies are small, spherical ~~cell~~ cell organelles bound by a unit membrane. They contain enzymes like oxidase, peroxidase and catalase. They were first discovered by Rhodin (1954).

Microbodies are found in the liver and kidney cells, protozoa and fungi. They have a short life-span of 4-5 days. Hence, they are regularly formed to replace the dead ones.

Microbodies arise from endoplasmic reticulum by budding. They are found in close association with endoplasmic reticulum, mitochondria and chloroplasts. They microbodies are mainly concerned with the metabolism of hydrogen peroxide (H_2O_2).

Microbodies are of two types :—

① Peroxisomes :- Animal cells & leaves of higher plants.
& ② Glyoxysomes - occur only in plants cells.

[1] Peroxisomes :—

Peroxisomes are small, granular microbodies containing peroxidases. They are found in protozoa, brown algae, fungi, liverworts, mosses, ferns, higher plants, also in liver and kidney.

Peroxisomes vary in size & shape, but usually appear circular in cross section having a diameter 0.2 - 1.5 Um. They have a single membrane made up of lipoproteins, which encloses granular matrix.

Peroxisomes produce oxidative enzymes called peroxidases. These enzymes include uric acid oxidase, D-amino oxidase & hydroxylic acid oxidase. These enzymes produce hydrogen peroxide (H_2O_2), which is toxic to the cell.

Peroxisomes produce another enzyme called catalase, which destroys H_2O_2 & protects the cell.

$$2H_2O_2 \longrightarrow 2H_2O + O_2 \uparrow$$

Peroxisomes oxidize a variety of substrates in a two step action :-

In the first step, substrates like amino acids, uric acid & lactic acid are oxidized by molecular O_2 to form H_2O_2. This oxidation is catalyzed by oxidases.

$$\text{Amino acid} + O_2 \xrightarrow{\text{Uric acid oxidase}} H_2O_2$$

$$\text{Uric acid} + O_2 \xrightarrow{\text{Amino acid oxidase}} H_2O_2$$

$$\text{Lactic acid} + O_2 \xrightarrow{\text{Hydroxyacid oxidase}} H_2O_2$$

Hydrogen peroxide (H_2O_2) is destructive to cells & has to be eliminated.

In the second step, substances like ethyl alcohol, methyl alcohol, nitrites, formic acid or another molecule of H_2O_2 is oxidized by the H_2O_2 formed in the first step. This reaction is catalyzed by another enzyme called catalase.

$$H_2O + \text{Ethyl alcohol} \xrightarrow{\text{Catalase}} 2H_2O$$

$$H_2O_2 + \text{Methyl alcohol} \xrightarrow{\text{Catalase}} 2H_2O$$

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

$$H_2O_2 + \text{Formic acid} \xrightarrow{\text{Catalase}} 2H_2O$$

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

The entire reaction carried out by peroxisomes can be summerized as follows :-

$$\underset{AH_2}{O_2} \xrightarrow[\text{oxidases}]{} \underset{A}{H_2O_2} \xrightarrow[BH_2]{\text{Catalase}} \underset{B}{2H_2O}$$

AH_2 & BH_2 are substrates and A & B are products.

2 Glyoxisomes :—

Glyoxisomes are small granular microbodies containing the enzymes of glyoxylate cycle. They are bound by a single membrane. They occur in cells of yeast, Neurospora and oil rich seeds of higher plants. They are abundant in germinating oilseeds. They are 6 µm in diameter.

Glyoxisomes contain enzymes which can convert lipid into carbohydrate, during which hydrogen peroxide (H_2O_2) is produced. They also contain catalase which decomposes H_2O_2 into water & oxygen.

Glyoxysomes are involved in triglyceride metabolism. The enzymes of glyoxysomes are used ~~for~~ to transform the stored fats of the seeds into carbohydrates by the way of glyoxylate cycle, which is the modification of Kreb's cycle.

The overall equation of this cycle is as follows :-

$$\text{Acetyl CoA} \longrightarrow \text{Succinic acid} + 2H^+ + 2\,\text{CoA}.$$

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