



BIOLOGY FOR ENGINEERS

MODULE 1

8.1 WHAT IS A CELL?

We know that the body of all living organisms is made up of cells which carry out certain basic functions. Hence the cells are called “**Basic structural and functional units of living organisms**”.

The classical branch of biology that deals with the study of structure, function and life history of a cell is called “**Cell Biology**”

- **Robert Hooke (1665):** He is an English scientist who observed honeycomb like dead cells in a thin slice of cork under microscope. He coined the term ‘cell’, which means a small room or compartment
- **Anton Von Leeuwenhoek (1667):** First saw and described living cell
- **Matthias J Schleiden (1838):** a German botanist based on his studies in different plant cells and **Theodore Schwann (1839)**, a British zoologist based on his studies on different animal cells formulated ‘**cell theory**’

8.2 CELL THEORY:

Cell theory was formulated by **M J Schleiden (1838)** and **Theodore Schwann (1839)**. The main principles of cell theory are

- All living organisms are composed of cells and products of cells
- All cells arise from pre existing cells through the process of cell division
- The body of living organisms is made up of one or more cells

8.3 ORGANISMS SHOW VARIETY IN CELL NUMBER, SHAPE AND SIZE

The invention of electron microscope and **staining techniques** helped scientists to study the detailed structure of cell.

The number of cells vary from a single cell to many cells in an organism. **The organisms made up of a single cell are called unicellular organisms.** These are capable of independent

existence. The single cell carries all the functions like digestion,

excretion, respiration, growth and reproduction. So, they are rightly called **acellular organisms**

Eg: *Amoeba*, *Euglena*, *Paramecium* etc.

The organisms made up of more than one cell are called multicellular organisms.

In multicellular organisms the cells vary in their shape and size depending on their function. The cells are spherical, oval, polyhedral, discoidal, spindle shaped, cylindrical in shape. The shape of the cells varies with the functions they perform.

Eg: Parenchyma cells – Polyhedral cells that perform storage function

Sclerenchyma cells – Spindle shaped cells that provide mechanical support

White blood cells – Amoeboid cells that defend the body against pathogens

Nerve cells – Long and branched that conduct nerve impulses

Muscle cells – cylindrical or spindle shaped cells concerned with the movement of body parts

Staining Technique: It is a technique of using dyes like eosin, safranin, Haematoxylin, fast green, methyleneblue to colour the parts of cells.

The size of the cell varies from few micrometers (μm) to few centimeters (cm). The size of bacteria varies from 0.1 to 0.5 μm . The smallest cell PPLO (Pleuro pneumonia like organism) is about 0.1 μ in diameter. The largest cell is an ostrich egg that measures 170 to 180 mm in diameter. Some Sclerenchyma fibres measure up to 60 cm in length. However the average size of the cell ranges from 0.5 to 10 μm in diameter.

Units of measurement

1cm = 10mm (millimeter), 1mm = 1000 μm (micrometers), 1 μm = 10000 \AA (Angstrom), $10\text{\AA} = 1\text{nm}$ (nanometer)

8.4 CELL STRUCTURE AND FUNCTION:

A typical cell has an outer non living layer called cell wall. The cell membrane is present below the cell wall. The cell membrane encloses protoplasm. The protoplasm has a semi fluid matrix called cytoplasm and a large membrane bound structure called Nucleus. The cytoplasm has many membrane bound structures like endoplasmic reticulum, golgibodies, mitochondria, plastids, micro bodies, vacuoles; and non membranous structures like Centrosome and ribosomes. These are called cell organelles. The cytoplasm without these cell organelles is called cytosol. The cytoplasm also contains non living inclusions called ergastic substances and cytoskeleton (microfilaments and microtubules)

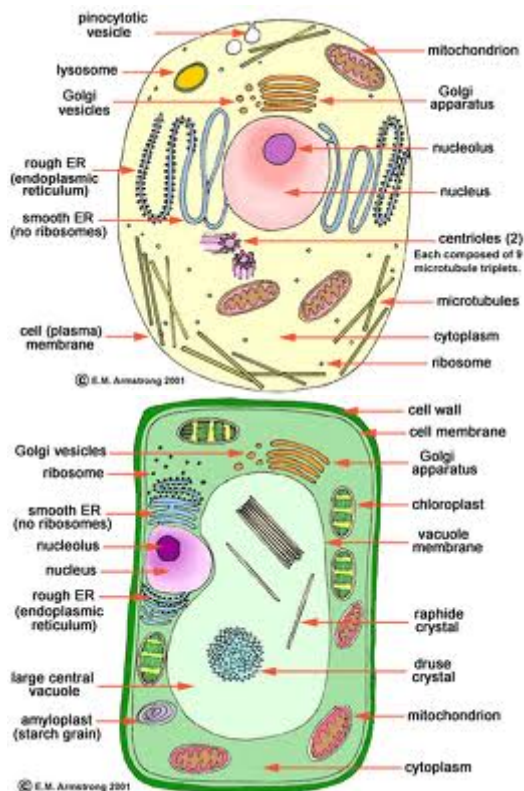


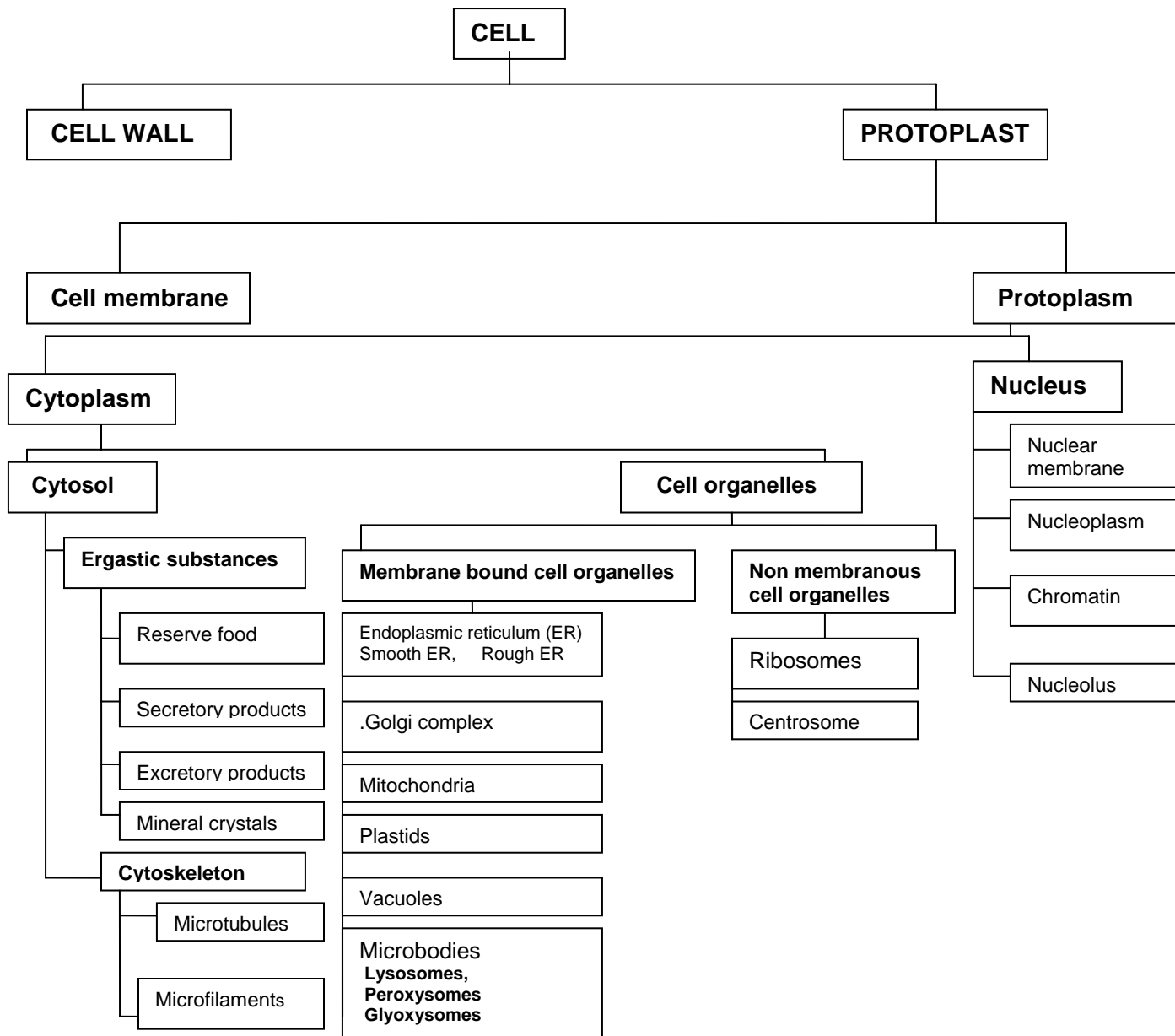
Fig. 8.1 ANIMAL CELL

The content of the cell within cell wall is called **protoplasm**. The cytoplasm without living cell organelles is called **cytosol**

Fig. 8.2 PLANT CELL

Comparison of plant and animal cell

Plant cell	Animal cell
Cell wall is present	Cell wall is absent
Centrioles are absent	Centrioles are present
Plastids are present	Plastids are absent
Have large vacuole	May have small vacuoles



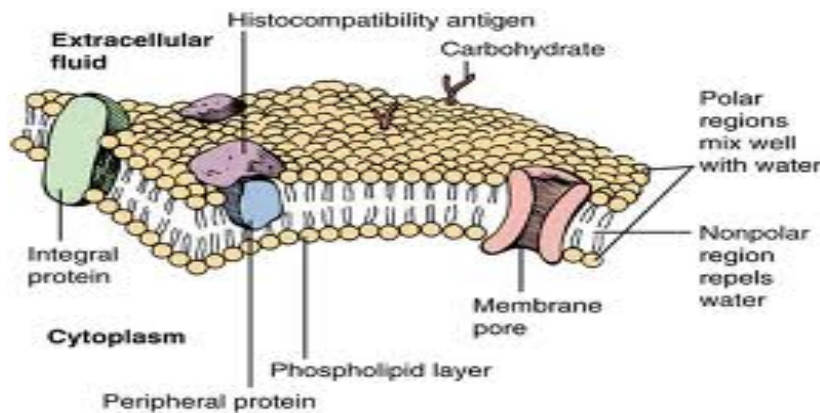
8.5 DESCRIPTION OF THE CELL CONTENTS

1. CELL WALL: It is an outer non living, rigid layer of cell. It is present in bacterial cells, fungal cells and plant cells. It is a permeable membrane chiefly composed of cellulose. It gives rigidity, mechanical support and protection to the cell.

2. PROTOPLAST: It includes cell membrane and protoplasm.

Cell wall of bacteria composed of peptidoglycans or murein complex.
Cell wall of fungi has chitin.

i) CELL MEMBRANE OR PLASMA MEMBRANE: It is a semi permeable membrane present in all cells. It is present below the cell wall in plant cell and outermost membrane in animal cell. It is composed of phospholipids, proteins, carbohydrates and cholesterol.



S.J.Singer and G. Nicolson (1974) proposed Fluid Mosaic model to describe the structure of plasma membrane.

Fig. 8.3 FLUID MOSAIC MODEL OF PLASMA MEMBRANE

Functions: It allows the outward and inward movement of molecules across it. The movement of molecules across the plasma membrane takes place by diffusion, osmosis, active transport, phagocytosis (cell eating) and pinocytosis (cell drinking).

ii) PROTOPLASM: It is a living substance of the cell that possesses all vital products made up of inorganic and organic molecules. It includes cytoplasm and nucleus.

Purkinje (1837) coined the term protoplasm. **Huxley** called protoplasm as “**physical basis of life**”

CYTOPLASM: It is the jellylike, semi fluid matrix present between the cell membrane and nuclear membrane. It has various living cell inclusions called **cell organelles** and non living cell inclusions called **ergastic substances and cytoskeletal elements**. The cytoplasm without cell organelles is called **cytosol**.

A. MEMBRANE BOUND CELL ORGANELLES PRESENT IN CYTOPLASM

1. ENDOPLASMIC RETICULUM (ER):

Discovery: Porter (1945)

Endoplasmic reticulum is a network of membrane bound tubular structures in the cytoplasm. It extends from cell membrane to nuclear membrane. It exists as flattened sacs called **cisternae**, unbranched **tubules** and oval **vesicles**.

There are two types of ER

Rough ER: It has 80s ribosomes on its surface

Smooth ER: It does not have ribosomes

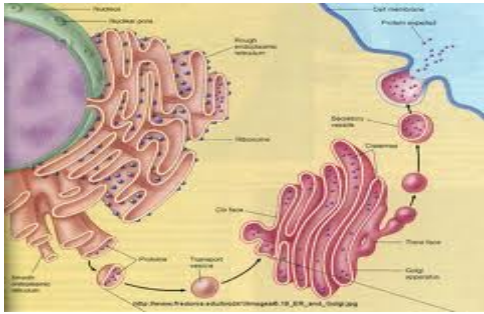


Fig. 8.4 ENDOPLASMIC RETICULUM

Functions:

- It helps in intracellular transportation
- It provides mechanical support to cytoplasmic matrix
- It helps in the formation of nuclear membrane and Golgi complex
- It helps in detoxification of metabolic wastes
- It is the store house of lipids and carbohydrates

2. GOLGI BODIES / GOLGI COMPLEX / GOLGI APPARATUS / DICTYOSOMES

Discovery: Camillo Golgi (1898), an Italian cytologist discovered Golgi bodies in the nerve cells of barn owl.

Golgi complex has a group of curved, flattened plate like compartments called **cisternae**. They stacked one above the other like pancakes. The cisternae produce a network of **tubules** from the periphery. These tubules end in spherical enzyme filled **vesicles**.

Common name: “Packaging centres” of the cell

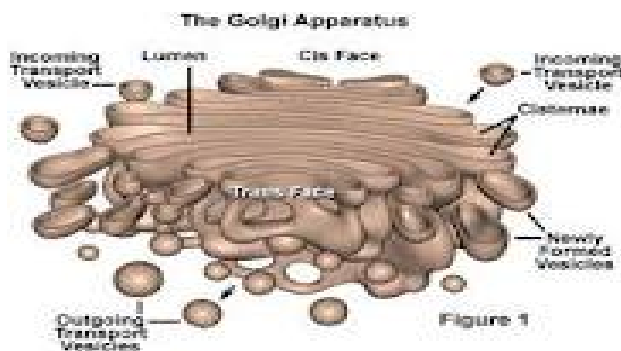


Fig. 8.5 GOLGI BODIES

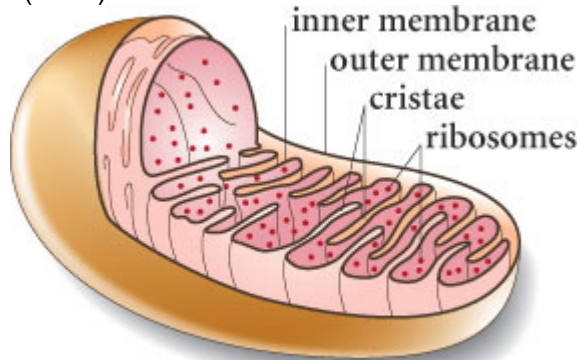
Functions:

- They pack enzymes, proteins, carbohydrates etc. in their vesicles, hence called packaging centres
- They produce Lysosomes
- They secrete various enzymes, hormones and cell wall material
- They help in phragmoplast formation

3. MITOCHONDRIA / CHONDRIOSOME

Discovery – Kolliker (1880)- discovered in the muscle cells of insects, **Altman** called them as **Bioplasts**,

Benda (1897) coined the term **Mitochondria**



Elizabeth Morales

Fig. 8.6 MITOCHONDRION

Mitochondrion is a spherical or rod shaped cell organelle. It has two membranes. The outer membrane is smooth. The inner membrane produces finger like infoldings called **cristae**. The inner membrane has stalked particles called **Racker's particles** or **F₀ – F₁ particles** or **Claude's particle** or **ATP synthase complex**. The mitochondrial cavity is filled with a homogenous granular **mitochondrial matrix**. The matrix has circular mitochondrial DNA, RNA, 70s ribosomes, proteins, enzymes and lipids.

Common name: Power houses of the cell / Storage batteries of the cell

Functions:

Mitochondria synthesise and store the energy rich molecules ATP (Adenosine triphosphate) during aerobic respiration. So, they are called "**Power houses of the cell**".

4. PLASTIDS:

Discovery: They were first observed by **AFW Schimper (1885)**

Plastids are present in plant cells and euglenoids.

Plastids are classified into three types based on the type of pigments.

1. **Chromoplasts:** These are different coloured plastids containing carotenoids. These are present in fruits, flower and leaves.
2. **Leucoplasts:** These are colourless plastids which store food materials.
Ex: Amyloplasts: Store starch
Aleuronoplasts: Store proteins
Elaeioplasts: Store lipids
3. **Choloroplasts:** These are green coloured plastids containing chlorophylls and carotenoids (carotenes & xanthophylls). Chloroplast is a double membranous cell organelle. The matrix is called **stroma**. The stroma has many membranous sacs called **Thylakoids**. They arrange one above the other like a pile of coins to form **Granum**. The grana are interconnected by **Fret membranes** or **Stroma lamellae** or **Intergranal membranes** or **Stromal thylakoids**. These membranous structures have photosynthetic pigments like chlorophylls, carotenes and xanthophylls (carotenols). They have four major complexes namely, photosystem I

(PSI), photosystem II (PSII), cytochrome $b_6 - f$ complex and ATP synthase. The **stroma** has a circular chloroplast DNA, RNA, 70s ribosomes, enzymes and co enzymes. Chloroplasts help in **photosynthesis**. (Synthesis of food molecules by utilizing CO_2 , water and solar energy)

Common name: Kitchen of the cell

Mitochondria and plastids have their own DNA called organelle DNA and 70s ribosomes. So, they are able to prepare their own proteins. Hence they are considered as '**semiautonomous cell organelles**'.

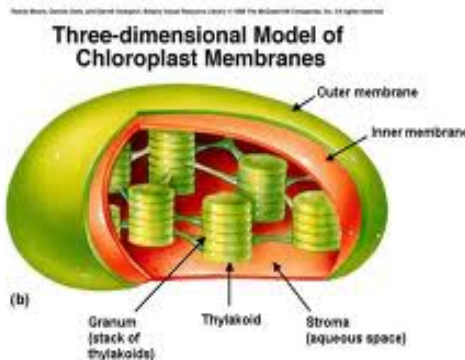


Fig. 8.7 STRUCTURE OF CHLOROPLAST

5. VACUOLES: Vacuoles are single membrane bound sac like vesicles present in cytoplasm. The plant cells have large vacuole and animal cells may have smaller vacuoles. The membrane of the vacuole is called **tonoplast**. Tonoplast is a semi permeable membrane. The vacuole is filled with a watery fluid called **cell sap**. The cell sap has dissolved salts, sugars, organic acids, pigments and enzymes.

There are different types of vacuoles. They are

- **Contractile vacuole:** These are present in fresh water protozoans and some algae. They take part in digestion, excretion and **osmoregulation** (maintenance of water balance)
- **Food vacuoles:** These are the vacuoles containing food particles. These are produced due to phagocytosis of cell.
- **Gas vacuoles:** These vacuoles contain gases and help in **buoyancy**.
- **Storage vacuoles:** These function like reservoirs and help in turgidity – flaccidity changes in plant cells

6. MICROBODIES: These are small, spherical, single membrane bound structures present in cytoplasm. The different types of microbodies are

a) Lysosomes: Discovery: Lysosomes are first reported by Belgian scientist **Christian de Duve** (1995) in rat liver cells. **Nivicott** (1950) coined Lysosomes

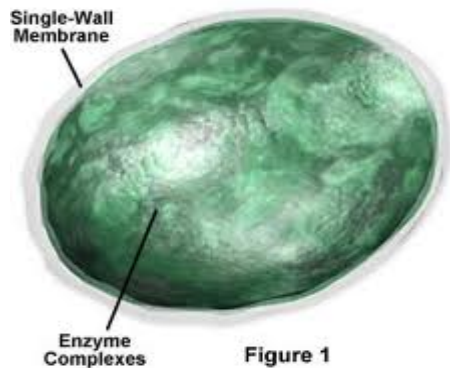
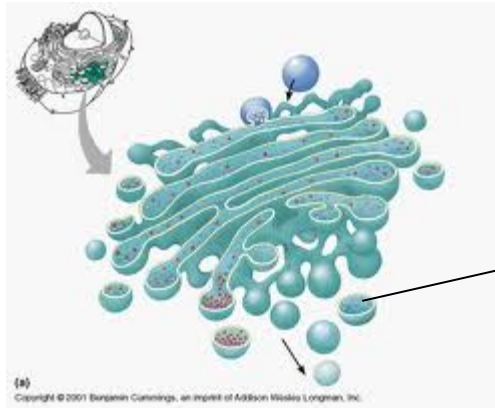


Figure 1

Fig. 8.7 STRUCTURE OF GOLGI BODIES PRODUCING LYSOSOME

Fig. 8.8 STRUCTURE OF LYSOSOME

These are small single membrane bound vesicles filled with **hydrolytic enzymes**. Lysosomes are produced from Golgi complex

The Lysosomal membrane is lipoproteic. It has stabilizers like cholesterol, cortisone, cortisol, vitamin E which give stability to the membrane. So, the enzymes do not digest the membrane.

The types of Lysosomes are

- **Primary Lysosomes:** Newly produced Lysosomes from golgibodies
- **Secondary Lysosomes (Phagolysosome):** These are formed by the union of phagosome and primary lysosome. It is also called **digestive vacuole**
- **Residual Lysosomes:** These are secondary Lysosomes left with undigested material which is thrown out by exocytosis
- **Autolysosomes (Autophagic lysosome):** These are formed by the union of primary lysosome and worn out cell organelles

Common name: Suicidal bags of cell / Time bombs of the cell / Recycling centers

Functions:

- They are concerned with intracellular digestion
- They contribute to ageing process
- They destroy old and non functional cells which bear them. (Autolysis). So they are called **suicidal bags**
- They break worn-out cells, damaged cells and cell organelles to component molecules for building new cell organelles. So they are called “**Recycling centers**”

b) Peroxisomes: These oxidize substrates producing hydrogen peroxide and involved in photorespiration

c) Glyoxysomes: These store fat and convert it into carbohydrates

B. NON MEMBRANOUS CELL ORGANELLES PRESENT IN THE CYTOPLASM

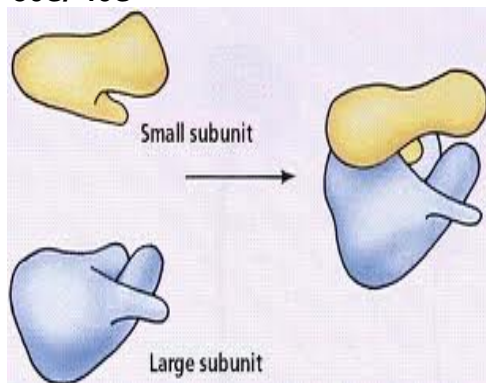
These organelles do not have any membranous covering. They are **Ribosomes** and **Centrosome**.

1. RIBOSOMES: Discovery: **K R Porter (1945)** - observed in animal cells, **Robinson and Brown (1953)** observed in plant cells, **George Plate (1953)** - coined the term Ribosome

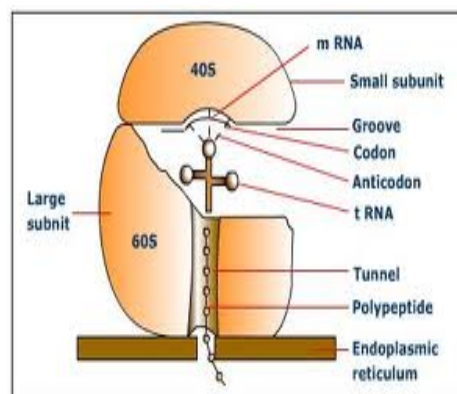
These are granular, nonmembranous sub spherical structures present in the cytoplasm, mitochondria and chloroplast. They are also found attached to Rough ER and nuclear membrane.

The ribosomes are composed of r-RNA and proteins. Prokaryotes have 70s (50s + 30s) ribosomes in cytoplasm. Eukaryotes have 80s (60s+40s) ribosomes in cytoplasm and 70s (50s +30s) ribosomes in mitochondria and plastids.

Common name: Protein factories of the cell
30S/ 40S



70S/80S



50S/ 60S

Fig. 8.9 STRUCTURE OF RIBOSOME

Function: These are the sites of polypeptide or protein synthesis

2. CENTROSOME: Discovery: Van Benden (1880)

Centrosome is found in animal cells and in some motile algae. It is absent in plant cells. It is present near the nucleus. Centrosome has two cylindrical structures called **centrioles** surrounded by a less denser cytosol called **centrosphere**. The centrioles are arranged at right angles to one another. Each centriole is made up of a whorl of nine triplets of microtubules. These microtubules run parallel to one another. The adjacent microtubules are connected by proteinaceous strands.



Fig. 8.10 STRUCTURE OF CENTROSOME

Functions:

- They form asters and organize the formation of spindle fibres during cell division.
- They are involved in the formation of cilia, flagella and axial filament in sperms.

NON-LIVING CELL INCLUSIONS

The non living cell inclusions includes **ergastic substances** and **cytoskeleton elements**

1. Ergastic substances: These are non living cell inclusions of cytoplasm like reserve food materials (starch, protein, oils), secretory products (nectar, pigments, enzymes), excretory products (alkaloids, resins, latex, tannins) and mineral crystals (cystoliths, raphides, druses).

Cystoliths: grape like cluster of calcium carbonate crystals

Raphides: Needle or rod like crystals of calcium oxalate.

The cells containing raphides are called **Idioblasts**

Druses (Sphaeroraphides): Spherical bodies containing calcium oxalate crystals

Secondary metabolites: These are not directly involved in the normal growth, development, or reproduction of an organism, unlike primary metabolites. The compounds like alkaloids, rubber, antibiotics, drugs, coloured pigments, scents, gums & spices are called secondary metabolites.

2. Cytoskeleton: It is a complex network of interconnected **microfilaments** and **microtubules** of protein fibres present in cytoplasm. The microfilaments are composed of **actin** and microtubules are composed of **tubulins**.

It helps in mechanical support, cell motility, cell division and maintenance of the shape of the cell.

B.NUCLEUS (KARYON) (plural – Nuclei)

Discovery: Robert Brown (1831) – discovered in the cells of orchids

Nucleus is a darkly stainable, largest cell organelle present in eukaryotic cells. It is usually spherical. It may be lobed in WBC, kidney shaped in paramecium.

Nucleus has an outer double layered **nuclear membrane** with **nuclear pores**, a transparent granular matrix called **nucleoplasm** or **karyolymph**, **chromatin network** composed of DNA and histones and a darkly stainable spherical body called **Nucleolus**.

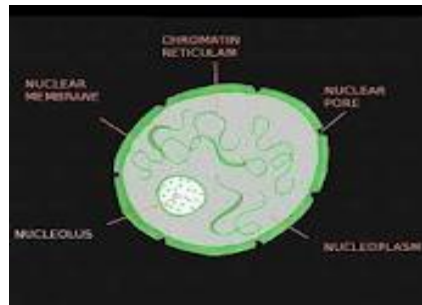


Fig. 8.11 STRUCTURE OF NUCLEUS

- The cells having nucleus are called **Nucleated or Eunucleated cells**
- The cells which lose nucleus at maturity are called **Enucleated cells**. Ex: Mammalian RBC, Sieve tube members of angiosperms
- The cells having incipient nucleus are called **prokaryotic cells** Ex: Bacteria, Nostoc
- The cells having well defined nucleus are called **Eukaryotic cells** Ex: Higher plant & animal cell

Nucleolus is called **ribosome factory** because it is involved in the synthesis of necessary molecules required for the production of ribosomes – discovered by **Fontana**

Prokaryotic cell: The cell having incipient or primitive nucleus is called prokaryotic cell. The nucleus does not contain nuclear membrane. It is genetic DNA or Genophore or Nucleoid or prochromosome. It has only DNA but not histones unlike eukaryotic cell. Eg: Bacteria, Blue green algae.

Eukaryotic cell: The cell having the nucleus with double layered nuclear membrane. Nucleus has chromatin composed of DNA and Histones Eg: cells of higher plants & animals

Function:

- Nucleus is the controlling centre of the cell
- It contains the genetic material DNA which regulates various metabolic activities of the body by directing the synthesis of structural and functional proteins

CHROMOSOME: The nucleus of a normal or non dividing cell has a loosened indistinct network of nucleoprotein fibers called **chromatin** (coined by **Flemming**). During cell division the chromatin condenses to form distinctly visible chromosomes.

Discovery: The term chromosome (chroma – colour, soma – body) was coined by **Waldeyer (1888)**, Discovered by **Hofmeister (1848)** observed in pollen mother cells of *Tradescantia*.

T H Morgan discovered the role of chromosome during transmission of characters and called them as '**vehicles of heredity**'.

A metaphase chromosome has two similar darkly stainable parallel strands called **chromatids** held at a point called **centromere**. Centromere is a less stained primary constricted region having **kinetochores & microtubules**. Each chromatid is made up of a highly coiled thread like structure called **chromonema** or chromatin fibre made up of **DNA and Histones**. The coiling of

chromonema results in bead like structures called **chromomeres**. At certain regions of chromosome is a tightly coiled, more stainable less active chromonema called **heterochromatin** and the loosely coiled, less stainable more active region called **euchromatin**. Chromosomes are classified into different types based on the position of centromere. They are Telocentric, acrocentric, submetacentric, metacentric chromosomes.

Functions: Chromosomes are the vehicles of heredity.

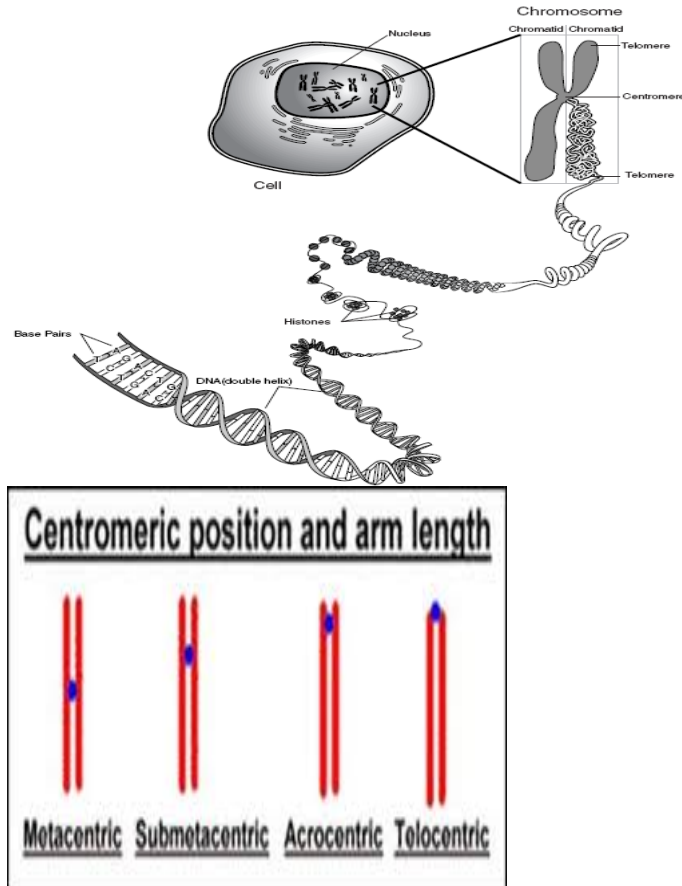


Fig. 8.12 STRUCTURE OF CHROMOSOME
CHROMOSOMES

Fig. 8.13 TYPES OF

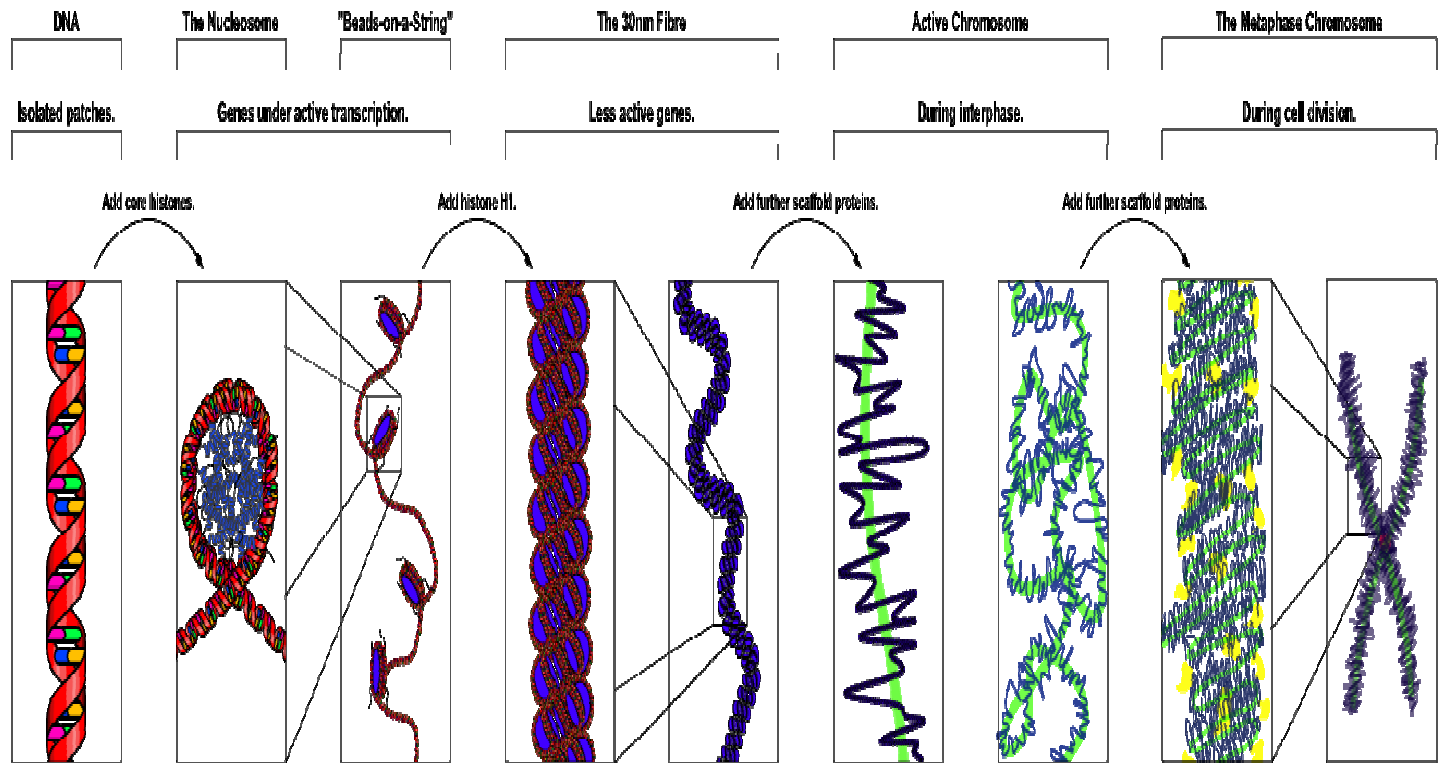


Fig. 8.14. ULTRA STRUCTURE OF CHROMOSOME SUMMARY

The body of all living organisms is made up of one or many cells. The cells vary in their shape, size and function. A typical cell has cell membrane, cytoplasm and nucleus. Plant cell has a cell wall outside the cell membrane. The cell wall is a permeable membrane that gives rigidity and definite shape to the cell. The plasma membrane is a semi permeable membrane that facilitates the movement of several molecules across it. The protoplasm is distinguished into cytoplasm and nucleus. The cytoplasm is a semi fluid matrix having living and non living components. It has many membrane bound cell organelles like Endoplasmic reticulum, Golgi bodies, Mitochondria, Plastids, Vacuoles and Microbodies. It is also having non membranous cell organelles like Ribosomes and Centrosome. The cytoplasm has non living cell inclusions like ergastic substances and cyto skeletal elements. The nucleus has nuclear membrane, nucleoplasm, nucleolus and chromatin. Each cell organelle performs various functions to maintain the living state of the cell.

Endoplasmic reticulum has membranous cisternae, tubules and vesicles. It helps in intracellular transport of substances and synthesis of proteins, carbohydrates and lipids. Golgi bodies also have cisternae, tubules and vesicles. It serves as a packaging industry, produce Lysosomes and secrete various enzymes. Mitochondrion has outer smooth membrane and the inner membrane is folded into finger like projections into the matrix called cristae. It helps in the production and storage of energy in the form of ATP molecules. Plastids are present in plant cells. Chloroplast has grana and stroma surrounded by two membranes. It helps in photosynthesis. Vacuoles have the membrane called tonoplast enclosing cell sap. Microbodies include lysosomes, Peroxisomes and Glyoxysomes. Lysosomes are single membranous spherical structures containing hydrolytic enzymes. They help in intracellular digestion. Ribosomes are granular structures having two subunits. They are involved in the process of protein synthesis. Centrosome has a pair of centrioles surrounded by a lesser denser cytosol



called centrosphere. Centrioles develop into asters and help in cell division. The ergastic substances include reserve food, secretory products excretory products and mineral crystals. The cytoskeletal element has a complex network of microfilaments and microtubules that give mechanical support to the cell. The nucleus is the largest cell organelle that regulates all the activities of the cell.

EXERCISE

1. Define cell.
2. What is cell biology?
3. Who formulated cell theory?
4. Mention the main principles of cell theory.
5. What is staining technique?
6. What are unicellular organisms? Give examples.
7. What are multicellular organisms?
8. What is protoplasm?
9. What is protoplast?
10. What is cytosol?
11. Name the membrane bound cell organelles present in cytoplasm.
12. Name the non membrane bound cell organelles present in cytoplasm.
13. Name the non living inclusions present in cytoplasm.
14. Mention the differences between plant cell and animal cell.
15. What is cell wall?
16. What is a plasma membrane?



17. What are the functions of plasma membrane?
18. What is considered as physical basis of life?
19. How does rough endoplasmic reticulum differ from smooth endoplasmic reticulum?
20. Mention any two functions of endoplasmic reticulum.
21. Mention the components of Golgi bodies.
22. Name the cell organelle that produces lysosomes.
23. What are cristae?
24. Why are mitochondria called Power houses of the cell?
25. Where are plastids present?
26. Mention the types of plastids.
27. What are Chromoplasts?
28. What are leucoplasts? Mention the types of leucoplasts.
29. Why are mitochondria and plastids called semiautonomous cell organelles?
30. Name single membrane bound cell organelles.
31. Name the membrane of a vacuole.
32. What is cell sap?
33. Mention the different types of vacuoles.
34. What are microbodies? Mention them.
35. What are lysosomes?
36. Why are lysosomes called suicidal bags?
37. Why are lysosomes called recycling centres?
38. What are ribosomes? Mention the types.
39. Mention any two functions of Centrosome.
40. What are ergastic substances? Mention them.
41. What are secondary metabolites? Give examples.
42. What is cytoskeleton? Mention its functions.
43. What is nucleus? Explain.
44. Why nucleolus is called ribosome factory?
45. What is enucleated cell? Give examples.
46. What is prokaryotic cell? Give example.
47. What is eukaryotic cell? Give example.
48. Mention the functions of nucleus.
49. What is chromatin?
50. What are chromatids?
51. What is centromere?
52. What is chromonema?
53. What are chromomeres?
54. What is heterochromatin?
55. What is euchromatin?
56. Mention the types of chromosomes based on the position of centromere.
57. Write the common names of following cell organelles.

ANSWERS

1. Cell is basic structural and functional units of living organisms.
2. Cell Biology is a classical branch of biology that deals with the study of structure, function and life history of a cell.
3. Matthias J Schleiden (1838): a German botanist based on his studies in different plant cells and Theodore Schwann (1839), a British zoologist based on his studies on different animal cells formulated 'cell theory'.
4. The main principles of cell theory are
 - All living organisms are composed of cells and products of cells
 - All cells arise from pre existing cells through the process of cell division
 - The body of living organisms is made up of one or more cells
5. Staining Technique is a technique of using dyes like eosin, safranin, Haematoxylin, fast green, methyleneblue to colour the parts of cells.
6. The organisms made up of a single cell are called unicellular organisms.
Eg: *Amoeba*, *Euglena*, *Paramecium* etc.
7. The organisms made up of more than one cell are called multicellular organisms.
8. The protoplasm is a semi fluid matrix containing cytoplasm and Nucleus.
9. The content of the cell within the cell wall is called protoplast.
10. The cytoplasm without living cell organelles is called cytosol.
11. The cytoplasm has many membrane bound cell organelles like endoplasmic reticulum, golgibodies, mitochondria, plastids, micro bodies and vacuoles.
12. The non membranous cell organelles present in cytoplasm are Centrosome and ribosomes.
13. The non living inclusions present in cytoplasm are ergastic substances and cytoskeletal elements (microfilaments and microtubules).

14.

Plant cell	Animal cell
Cell wall is present	Cell wall is absent
Centrioles are absent	Centrioles are present
Plastids are present	Plastids are absent
Have large vacuole	May have small vacuoles

15. Cell wall is a permeable, outer non living, rigid layer present in bacterial cells, fungal cells and plant cells.



16. It is a semi permeable membrane present in all cells. It is present below the cell wall in plant cell and outermost membrane in animal cell.

17. Plasma membrane allows the outward and inward movement of molecules across it by the process of diffusion, osmosis, active transport, phagocytosis (cell eating) and pinocytosis (cell drinking).

18. Protoplasm is considered as “physical basis of life”, by Huxley.

19. Rough ER has ribosomes on its surface while smooth ER does not have ribosomes.

20.

- It helps in intracellular transportation
- It helps in the formation of nuclear membrane and Golgi complex

21. Golgi complex has a group of curved, flattened plate like compartments called cisternae. The cisternae produce a network of tubules from the periphery. These tubules end in spherical and enzyme filled vesicles.

22. Golgibodies.

23. The inner membrane of mitochondria produces finger like infoldings called cristae.

24. Mitochondria synthesise and store the energy rich molecules ATP (Adenosine triphosphate) during aerobic respiration. So, they are called “Power houses of the cell”.

25. Plastids are present in plant cells and euglenoids.

26. The types of plastids are chloroplast, chromoplast and leucoplast.

27. Chromoplasts are different coloured plastids containing carotenoids. These are present in fruits, flower and leaves.

28. Leucoplasts are colourless plastids which store food substances. The types of leucoplasts are

Amyloplasts - Store starch; Aleuronoplasts - Store proteins and Elaeioplasts- Store lipids.

29. Mitochondria and plastids have their own DNA called organelle DNA and 70s ribosomes. So, they are able to prepare their own proteins. Hence they are called semiautonomous cell organelles.

30. The single membrane bound cell organelles are vacuoles and Lysosomes.

31. Tonoplast.

32. The vacuole is filled with watery fluid called cell sap. The cell sap has dissolved salts, sugars, organic acids, pigments and enzymes.

33. The different types of vacuoles are

- Contractile vacuole



- Food vacuoles
- Gas vacuoles
- Storage vacuoles

34. Microbodies are small, spherical, single membrane bound structures present in cytoplasm. They are

Lysosomes and centrosome.

35. Lysosomes are small single membrane bound vesicles filled with hydrolytic enzymes.

36. Lysosomes destroy old and non functional cells which bear them (Autolysis). So they are called suicidal bags

37. Lysosomes break worn-out cells, damaged cells and cell organelles to component molecules for building new cell organelles. So they are called recycling centers.

38. Ribosomes are granular, nonmembranous sub spherical structures present in the cytoplasm, mitochondria and chloroplast. The types are 70s (50s + 30s) ribosome and 80s (60s+40s) ribosome.

39. The functions are,

- They form asters and organize the formation of spindle fibres during cell division.
- They are involved in the formation of cilia, flagella and axial filament in sperms.

40. Ergastic substances are non living cell inclusions of cytoplasm like reserve food materials (starch, protein, oils), secretory products (nectar, pigments, enzymes), excretory products (alkaloids, resins, latex, tannins) and mineral crystals (cystoliths, raphides, druses).

41. Secondary metabolites are organic compounds that are not directly involved in the normal growth, development, or reproduction of an organism, unlike primary metabolites, The compounds like alkaloids, rubber, antibiotics, drugs, coloured pigments, scents, gums & spices are called secondary metabolites.

42. Cytoskeleton is a complex network of interconnected microfilaments and microtubules of protein fibres present in cytoplasm. The microfilaments are composed of actin and microtubules are composed of tubulins.

It helps in mechanical support, cell motility, cell division and maintenance of the shape of the cell.

43. Nucleus is a darkly stainable, largest cell organelle present in eukaryotic cells. Nucleus has an outer double layered nuclear membrane with nuclear pores, a transparent granular matrix called nucleoplasm or karyolymph, chromatin network composed of DNA and histones and a darkly stainable spherical body called Nucleolus.

44. Nucleolus is called ribosome factory because it is involved in the synthesis of necessary molecules required for the production of ribosomes.

45. The cells which lose nucleus at maturity are called Enucleated cells. Eg: Mammalian RBC, Sieve tube members of angiosperms.



46. The cell having incipient nucleus is called prokaryotic cell. Eg: Bacteria, Nostoc
47. The cell having well defined nucleus with double layered nuclear membrane is called eukaryotic cell
Eg: cells of higher plants & animals
- 48.
- Nucleus is the controlling centre of the cell
 - It contains the genetic material DNA which regulates various metabolic activities of the body by directing the synthesis of structural and functional proteins
49. The nucleus of a normal or non dividing cell has a loosened indistinct network of nucleoprotein fibers called chromatin. It is a diffused network of chromosomes.
50. A metaphase chromosome has two similar dark, stainable parallel strands called chromatids held at a point called centromere.
51. Centromere is a less stained primary constricted region of chromosome having kinetochores & microtubules.
52. Each chromatid is made up of a highly coiled thread like structure called chromonema or chromatin fibre made up of DNA and Histones.
53. Chromomeres are bead like structures formed due to coiling of chromonema. These occur in Leptotene stage of meiosis.
54. The chromosome has a tightly coiled, more stainable less active chromonema called heterochromatin.
55. The chromosome has a loosely coiled, less stainable more active region called euchromatin.
56. They are Telocentric, acrocentric, submetacentric, metacentric chromosomes.
57. a) Golgi bodies – packaging centres
b) Mitochondria – power house of the cell / storage batteries of the cell
c) Chloroplast – kitchen of the cell
d) Lysosomes - suicidal bags of the cell / recycling centres of the cell
e) Ribosomes – protein factories
f) Nucleolus – Ribosome factory