TOPIC: CELL STRUCTURE AND MICROSCOPY

The cell is a basic unit of life. A cell carries out a number of activities including protein synthesis, cell division and it is where the hereditary material is. Specialized cells constitute tissues.
The study of cells is known as **cytology**.

The cell theory states that;

1. All living organisms are composed of cells.
2. All new cells are derived from other cells.
3. Cells contain the hereditary material of an organism which is passed on from parent to daughter cells.
4. All metabolic processes take place within cells.

Investigation of the cell structure

Cells are investigated using microscopes. There are 2 main types of microscopes, i.e.

- Compound light microscope
- Electron microscope

1) The compound light microscope:

This is a type of microscope that uses light to investigate structures. Two lenses are used i.e., objective lens and the ocular lens (eye piece lens).
Light from an object passes through the first lens (objective) and produces a magnified image which acts as the object for the second lens (eye piece lens) which further magnifies it.
The degree of detail which can be seen with a microscope is called its ***resolution (resolving power)***. This measures its ability to distinguish objects close together.

2) The electron microscope:

It works on the same principle as the light microscope but instead of light rays, a beam of electrons is used. It magnifies objects over 500,000 times which compares with the best light microscope that magnifies only 1500 times.
Whereas the light microscope uses glass lenses to focus light rays, the electron beam of the electron microscope is focused using electron beams.
The image produced cannot be detected by a naked eye but is directed on a screen from which black and white photographs called photoelectron micrographs can be seen.

Magnification can be calculated using the formula **(magnification =$\frac{image\ size}{actual\ size}$)**

Advantages and disadvantages of the light and electron microscope

Light microscope	**Electron microscope**
(advantages)	**(disadvantages)**
It is easy and cheap to operate since it uses little or no electricity.	It is difficult and expensive to operate since it requires much electricity to produce an electron beam.
The natural colour of the specimen can be observed.	All images are in black and white.
It is small and portable.	It is very large and operated in special rooms.
It can view living and dead materials.	The high vacuum required kills the living materials.
Preparation of material is quick.	Preparation of material is lengthy and requires special equipment.
Materials are not changed or distorted by preparation.	Materials are changed or distorted by preparation.
Disadvantages	**Advantages**
It has a low resolving power i.e., 200nm.	Has a high resolving power of about 1nm.
It has a low magnifying power i.e., up to 1500 times.	Has a high magnifying power i.e. up to 500,000 times.

Metric units of conversion

The units of size are:
One kilometer (km) = 1000 meters (10^3 m)
One meter (m) = 10^0 meters (1m)
One centimeter (cm) = $^1/_{100}$ meters (10^{-2} m)
One millimeter (mm) = $^1/_{1000}$ meters (10^{-3} m)
One micrometer/micron (μm) = $^1/_{1000000}$ meters (10^{-6} m)
One nanometer (nm) = 10^{-9} m
One picometer (pm) = 10^{-12} m

Trial questions;

1. If the magnification of the microscope is 50,000 times and the size of the image viewed is five (5) mm. what is the actual size of the object in microns.
2. A specimen observed under a microscope measures 50mm and the actual specimen measured 5.0 micrometers. What is the magnification of the specimen under the microscope?

CYTOLOGY

All cells are self-contained and self-sufficient units. They are surrounded by a cell membrane and have a nucleus or nuclear area.

Types of cells

There are two types of cells grouped according to their structure. They include ***prokaryotic and eukaryotic cells.***

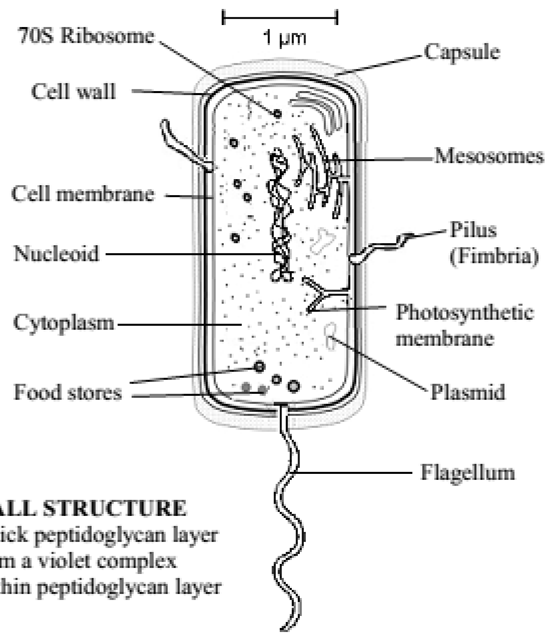
Structure of prokaryotic cells

These are cells of bacteria. They are referred to as primitive cells because they are believed to have occurred in the earliest organisms. Their DNA (Deoxyribose Nucleic Acid) is not enclosed within a nuclear membrane therefore have no true nucleus. Such cells also have no membrane bound organelles.

ULTRASTRUCTURE OF PROKARYOTIC CELL (e.g. ROD-SHAPED BACTERIUM)

Parts **ALWAYS** present

- ***70S ribosome:*** site of protein synthesis
- ***Cell wall:*** peptidoglycan layer that protects and maintains cell shape
- ***Cell membrane:*** phospholipid layer controls entry and exit of substances.
- ***Nucleoid:*** region of one free strand of DNA
- ***Food granules:*** glycogen and lipid
- ***Cytoplasm:*** centre for biochemical reactions.



Parts **SOMETIMES** present

- ***Mesosome:*** site of respiration, cell wall synthesis
- ***Flagellum:*** elongated, relatively flexible cork-screw shaped structure that moves the cell
- ***Capsule (slime layer):*** for protection
- ***Pili (fimbriae):*** protein filaments that facilitate cell adhesion and conjugation
- ***Plasmid:*** independent small circle of DNA
  - Offers resistance to drugs
- ***Photosynthetic membranes:*** where photosynthesis occurs.

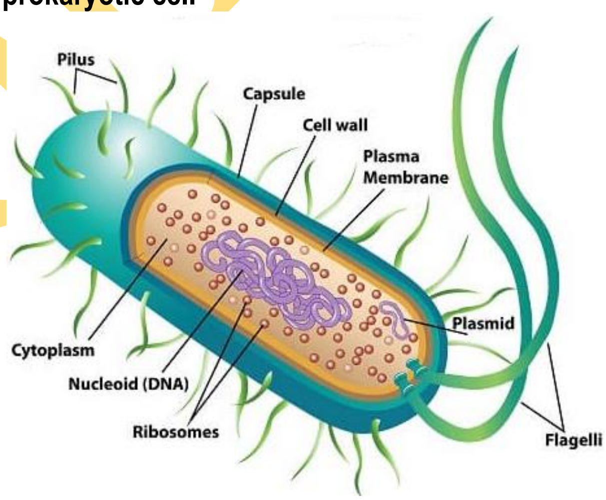
DIFFERENCES IN CELL WALL STRUCTURE

(i) Gram positive cells: Have thick peptidoglycan layer that reacts with gram stain to form a violet complex

(ii) Gram negative cells: Have thin peptidoglycan layer that is not stained by gram stain.

Functions of the parts of a prokaryotic cell

i) **70S ribosomes:** this is the site of protein synthesis.
ii) **Cell wall:** it protects and maintains shape.
iii) **Cell membrane:** controls entry and exit of substances.
iv) **Nucleotide:** region of one free strand of DNA.
v) **Food granules:** this includes glycogen and lipid granules.
vi) **Cytoplasm:** center for bio-chemical reactions.



The following parts are sometimes present:

- **Mesosome:** site of respiration. It may also be involved in cell division. The mesosome is an in-folding of the cell membrane.
- **Flagella:** this propels the bacterium along.
- **Capsule (slimy layer):** for protection.
- **Pili (fimbriae):** these are protein filaments that facilitate cell adhesion and conjugation.
- **Plasmid:** this is an independent small circle of DNA. It also offers resistance to drugs.

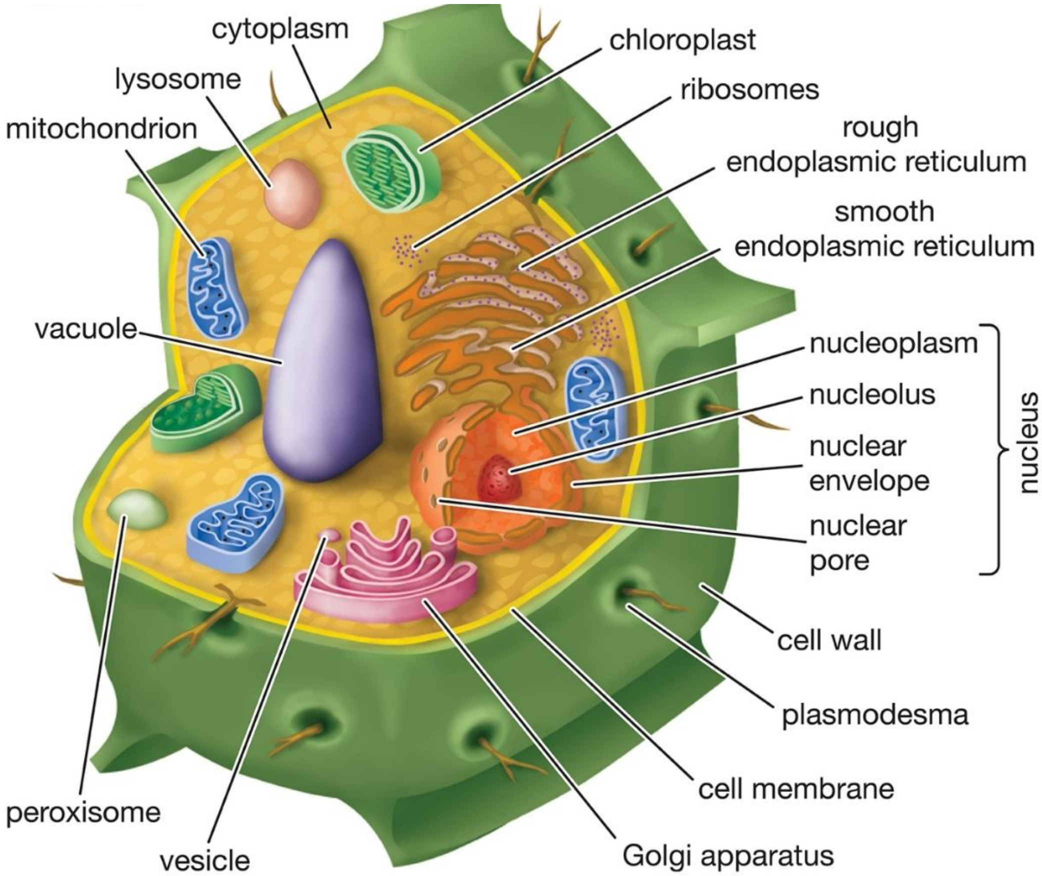
The structure of eukaryotic cells

These are true cells that developed from prokaryotic cells. This development involved several stages which include:

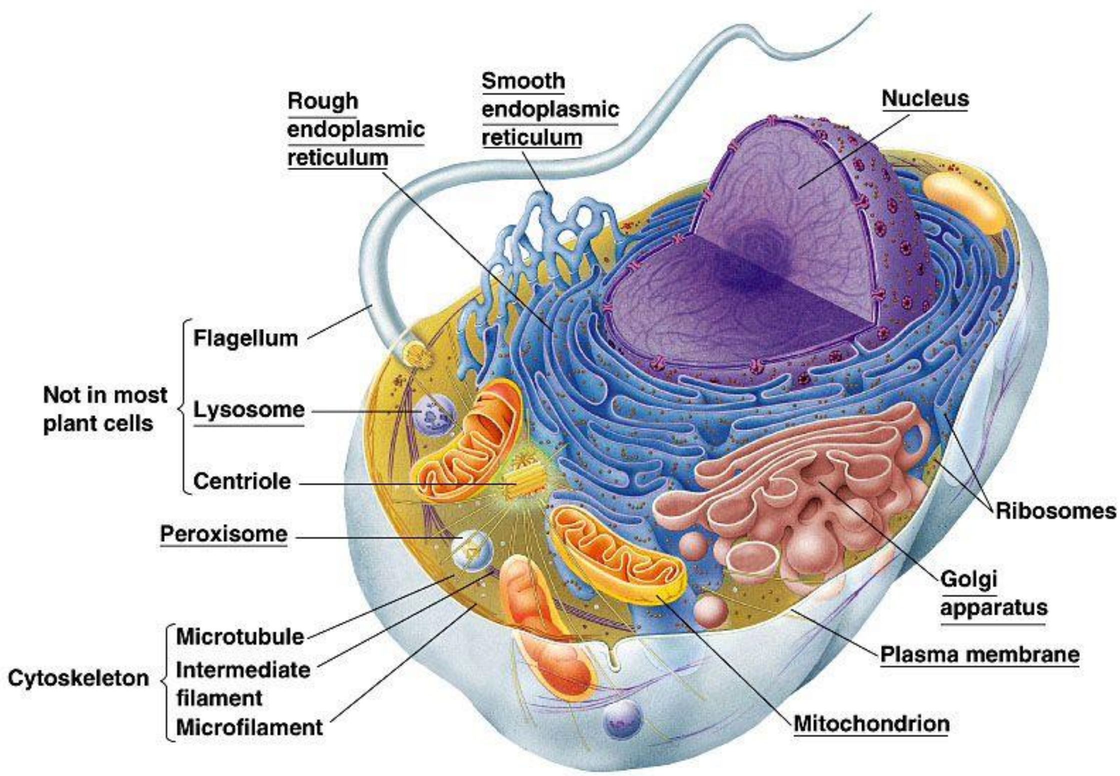
i) Development of a nuclear membrane around the nuclear material forming a true nucleus.
ii) Development of membrane bounded organelles e.g., mitochondria and nucleus within the cytoplasm of the cell.

There are two main types of eukaryotic cells i.e., the plant cell and animal cell.

Structure of a plant cell



Structure of the animal cell



Differences between prokaryotic and eukaryotic cells

Prokaryotic cells	Eukaryotic cells
They lack a true nucleus since the genetic material is naked with scattered areas of nucleoplasm with no nuclear membrane.	Have a true nucleus with a membrane binding the genetic material.
There are no chromosomes but only circular strands of DNA.	Chromosomes are present on which DNA is located.
No mitosis or meiosis occurs.	Mitosis and meiosis occur.
Lack the membrane bounded organelles e.g., chloroplast, mitochondria.	Have membrane bounded organelles.
Flagella if present lack the 9+2 fibril arrangement.	Flagella have the 9+2 internal fibril arrangement.
Ribosomes are smaller.	Ribosomes are larger.

Differences between plant and animal cells

Plant cells	Animal cells
Cell wall present in addition to the cell membrane.	Cell wall absent, only cell membrane surrounds the cell.
Pits and plasmodesmata present.	Pits and plasmodesmata absent.
Plastids e.g., chloroplasts and leucoplasts are present.	Plastids absent.
Mature cells have large single central vacuole filled with cell sap.	Vacuoles e.g., contractile vacuoles if present are small and scattered throughout the cell.
Tonoplast present around the vacuole.	Tonoplast absent.
Cytoplasm confined to a thin layer at the edge of the cell.	Cytoplasm present throughout the cell.
Nucleus at the edge of the cell.	Nucleus anywhere in the cell but often central.
Lysosomes absent.	Lysosomes present.
Cilia and flagella absent.	Cilia and flagella present.
Starch granules used for storage.	Glycogen granules used for storage.
Middle lamella present.	Middle lamella absent.
Only meristematic cells are capable of division.	All cells are capable of division.
Few secretions released.	A variety of secretions released.

Structure of cellular parts and their functions

These include all cell organelles, the components within the cytoplasm, cell membrane and cell wall.

An organelle is a distinct part of the cell which is membrane bound having a particular function for the cell. The most important organelles are:

Endoplasmic reticulum, Golgi body, mitochondrion, plastids such as chloroplasts, ribosomes, cell vacuoles and nucleus.

Other cellular parts which aren't organelles are; microtubules, centrioles, cell wall, cytoplasm, microfilaments, cell membrane and cytosol (cytosol is the liquid found inside cells).

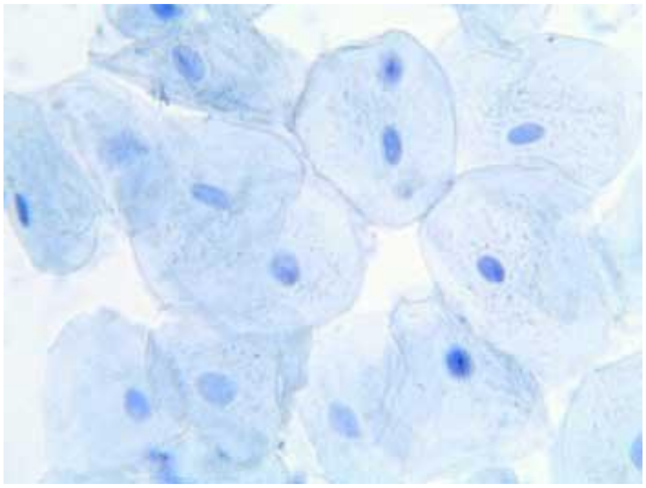
Note: Whereas ***cytosol*** is the fluid contained in the cell cytoplasm, ***cytoplasm*** is the entire content within the cell membrane.

Protoplasm is the translucent material comprising the living part of plant and animal cells, including the cytoplasm, nucleus, and other organelles. The main difference between cytoplasm and protoplasm is that cytoplasm is all the contents inside the cell membrane excluding the nucleus yet protoplasm includes cytoplasm plus the nucleus of the cell. **Protoplast** is the protoplasm of a living plant or bacterial cell whose cell wall has been removed.

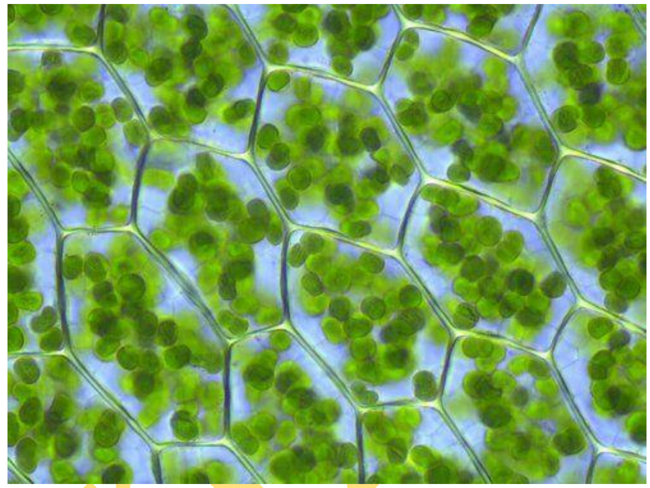
Assignment:

Draw four adjacent cells from each of the images below as seen under a light microscope. Write titles to your drawings and label the parts seen.

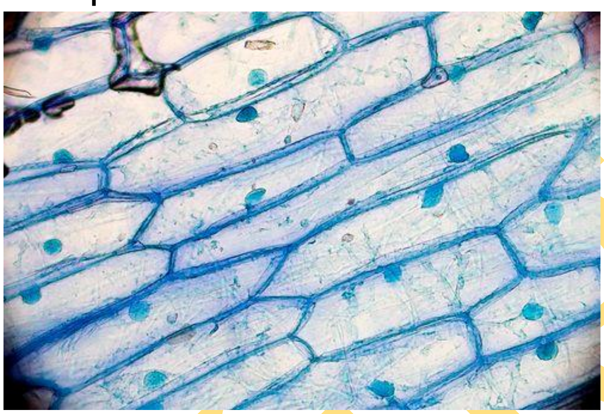
Animal cheek cells:



Plant leaf cells:



Plant epidermal cells:



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1. Cytoplasm.

All cell organelles are contained within the cytoplasmic cell known as cytoplasm.
It also contains storage materials like oil droplets, starch granules and glucose granules.
It is a site for many bio-chemical processes like glycolysis.
It is not static but capable of mass flow which is known as cytoplasmic streaming.

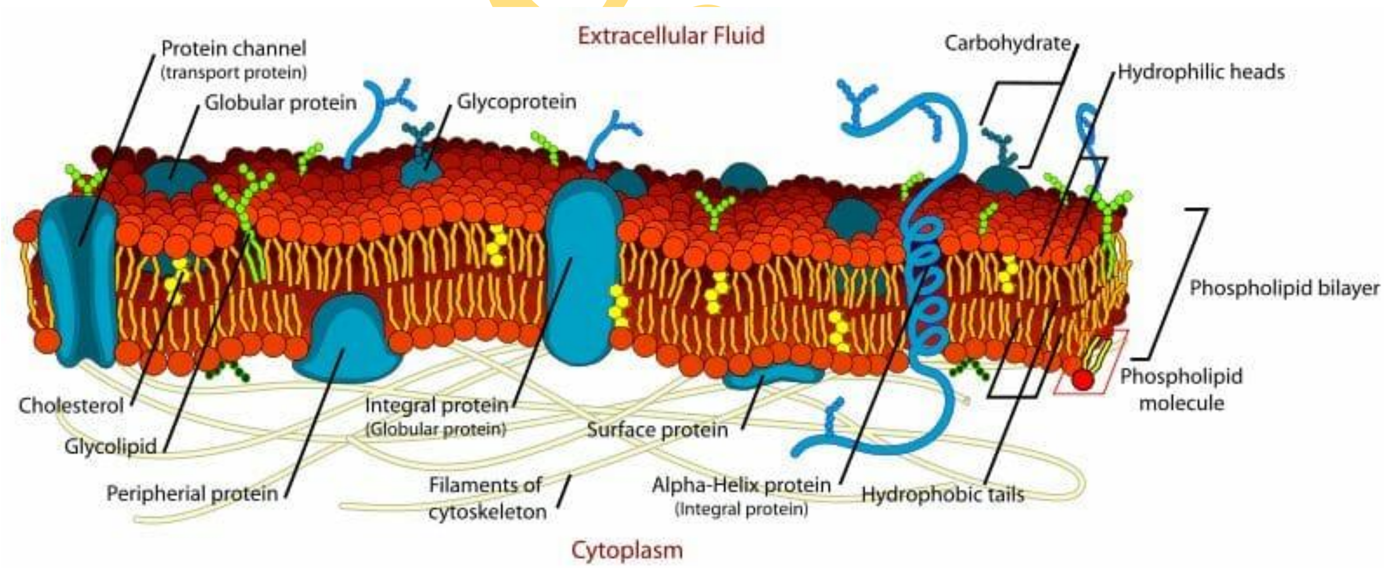
2. Cell membrane.

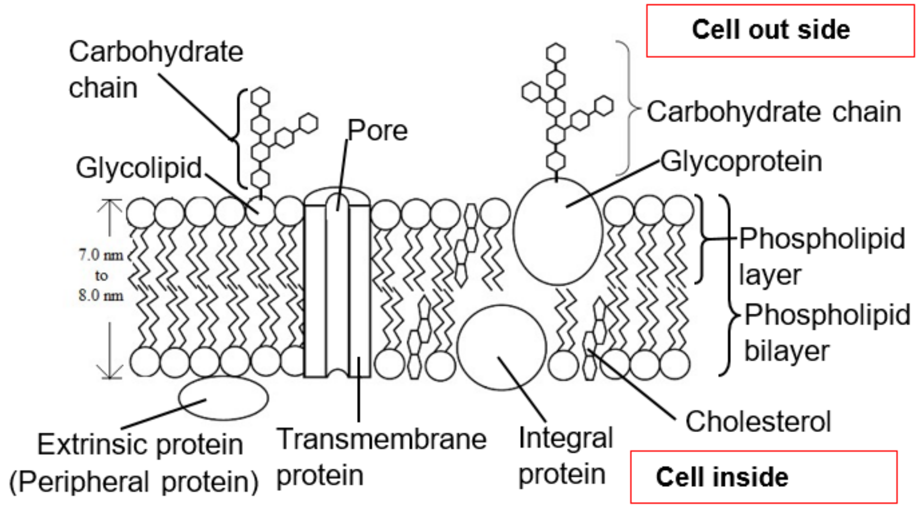
This is also referred to as the plasma membrane which covers cells to separate them from external environment.
In eukaryotic cells however, there are two types of membranes i.e., plasma membrane which binds the cell and intracellular membranes which bind other organelles within the cell. All membranes of the cell have the same basic structure.
Some substances can pass freely in and out of the membrane yet others can be excluded at one moment only to pass freely across at another occasion. Due to this, the membrane is said to be partially or semi permeable.

Structure of the plasma membrane

It is believed that the cell membrane is made up of mainly two chemical groups i.e., proteins and phospholipids as explained by the ***fluid mosaic theory*** of the structure of the plasma membrane.
According to Singer and Nicholson (1972), the structure of the plasma membrane is a fluid-mosaic model.
It is described as fluid because the individual phospholipids and protein molecules can move laterally, giving the membrane a flexible structure that is constantly changing in shape.
It is mosaic because the proteins that are embedded in the phospholipids bi-layer vary in size, shape and pattern of arrangement.
The components of the cell membrane are: Proteins, Phospholipids, Carbohydrates and Cholesterol.

Structure of the cell membrane





Description of the structure of cell membrane:

- It is made up of two layers of phospholipds (phospholipd bi-layer) whose lipids face inwards of the membrane while phosphate heads face outwards;
- The phosphate heads are polar, hydrophilic and form hydrogen bonds with water;
- The lipid tails are non-polar, hydrophobic and are attracted to each other by hydrophobic interactions;
- Extrinsic proteins are found at the inner and outer surface. Some intrinsic proteins are partly embedded in anyone of the phospholipid layer while others span across the two phospholipd bi-layer (transmembrane protein);
- Some transmembrane proteins are porous. Some phospholipids conjugate with short branched carbohydrates to form glycoproteins;
- Some phospholipids conjugate with short branched carbohydrates to form glycolipids;
- In animal cells, the cholesterol squeeze through phospholipid molecules;

Revision questions:

1. *Describe six roles of the cell membrane proteins.*
2. *How is the cell membrane suited to its functions?*
3. *What are the main ideas of the cell theory?*
4. *Describe the structure of the plasma membrane.*

Functions of the cell membrane

The phospholipid bi-layer provides the basic structure of membranes. It also restricts entry and exit of polar molecules and ions. The other components have a variety of functions which include:

i) Proteins:

- Glycoproteins work as antigens in immunity.
- Channel proteins allow diffusion of polar ions and molecules across the membrane.
- Transport proteins move ions or solutes by active transport e.g., sodium ions or by facilitated diffusion e.g., glucose, amino acids across the membrane.
- Membrane proteins provide sites for cytoskeleton filaments to anchor to support and maintain cell shape.
- Membrane proteins join cells together forming tissues which perform specific functions.

- Glycoproteins are involved in cell-to-cell recognition by cells of complimentary sites.
- Glycoproteins have very specific shapes. This makes them ideal as receptor molecules for chemical signaling between the cells e.g., hormones are chemical messages which circulate in blood but only bind to specific target cells which have the correct receptor sites.
- Cell surface receptor proteins are involved in signal-transduction by converting an extracellular signal to an intracellular one.
- Some membrane proteins have enzymatic properties e.g., ATP synthase for ATP synthesis.
- Some membrane proteins work as electron carriers in electron transport chains.

ii) Glycolipids:

- Are involved in cell-to-cell recognition.

iii) Cholesterol:

- Stabilizes membrane structure by preventing phospholipids from closely packing together.
- Act like a plug, reducing even further the escape or entry of polar molecules through the membrane.

iv) The lipid bilayer:

- Being semi-permeable, it controls movement of substances in and out of the cell.

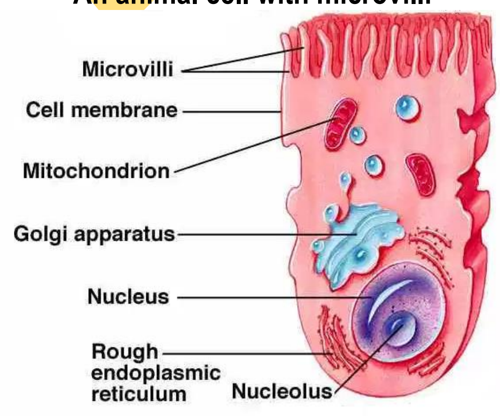
3. Microvilli:

These are tiny finger-like projections about 0.6 micro meters in length on the membranes of certain cells e.g., those lining the intestines and kidney tubules.

The microvilli are massed together and appear similar to bristles of a brush hence the term brush border given to the age of cells having microvilli.

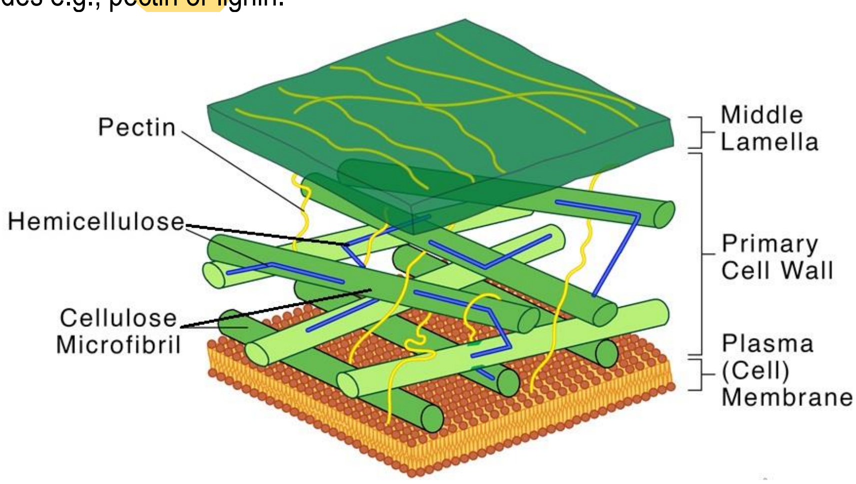
Each microvillus contains bundles of actin and myosin filaments hence allowing them to contract which along with their large surface area facilitate absorption of materials.

An animal cell with microvilli



4. Cell wall:

It is found in plant cells and made up of cellulose micro fibrils embedded in an amorphous polysaccharide matrix. The matrix has polysaccharides e.g., pectin or lignin.



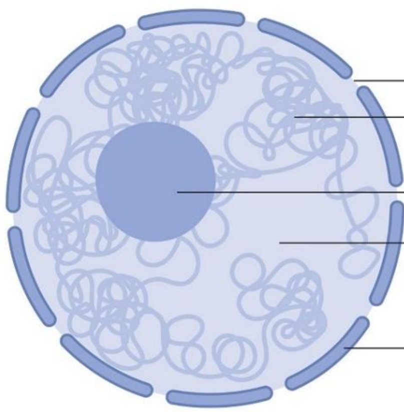
Functions of a cell wall

i) It provides support in herbaceous plants. As water enters the cell osmotically, the cell wall resists expansion and internal pressure is created which provides turgidity of the cell and the plant as a whole.
ii) It gives direct support to the cell and the plant by providing mechanical strength. The strength may be increased by presence of lignin in the matrix between the cellulose fibres.
iii) It allows movement of water through and along it hence contributing to movement of water in the plant as a whole especially in the cortex of the root.
iv) It stops loss of materials from the cell to the outside since it is less permeable than the cell membrane.
v) The arrangement of the cellulose fibrils in the cell wall gives the overall shape of the cell.

Membrane-bound organelles

1. Nucleus

This is the most prominent feature of the cell. Its shape, size, position and its chemical composition of the cell vary from cell to cell but its functions are always the same, mainly to control the cell's activities and to retain the organism's hereditary materials (chromosomes).



Description of the structure

Cell nucleus is enclosed by a double-layered nuclear membrane (nuclear envelope); The outer membrane is connected to the endoplasmic reticulum;
A fluid-filled space (perinuclear space) exists between the two layers of a nuclear membrane; The nuclear membrane is perforated by tiny nuclear pores;
Enclosed within the inner membrane are the nucleoplasm, nucleolus and chromosomes (chromatin); Nucleolus is a dense, spherical-shaped structure; Chromosomes (chromatin) are thread-like.

Functions of the nucleus

i) Controls the heredity features of an organism.
ii) Controls protein synthesis, cell division, growth and differentiation.
iii) Stores DNA, the heredity material.
iv) Stores proteins and RNA in the nucleolus.
v) Site for transcription in which messenger RNA are produced for protein synthesis.
vi) Nucleolus produces ribosomes, which are the protein factories.

Adaptations of the nucleus

- DNA is long to store many genes.
- Nuclear membrane has pores for exchange of DNA and RNA between the nucleus and cytoplasm.
- Presence of nucleolus enables production of ribosomes which are protein factories.
- Nuclear envelope isolate nucleus from interference by processes in cytoplasm.
- Nuclear pores are narrow to regulate entry and exit of substances.

2. Chloroplasts:

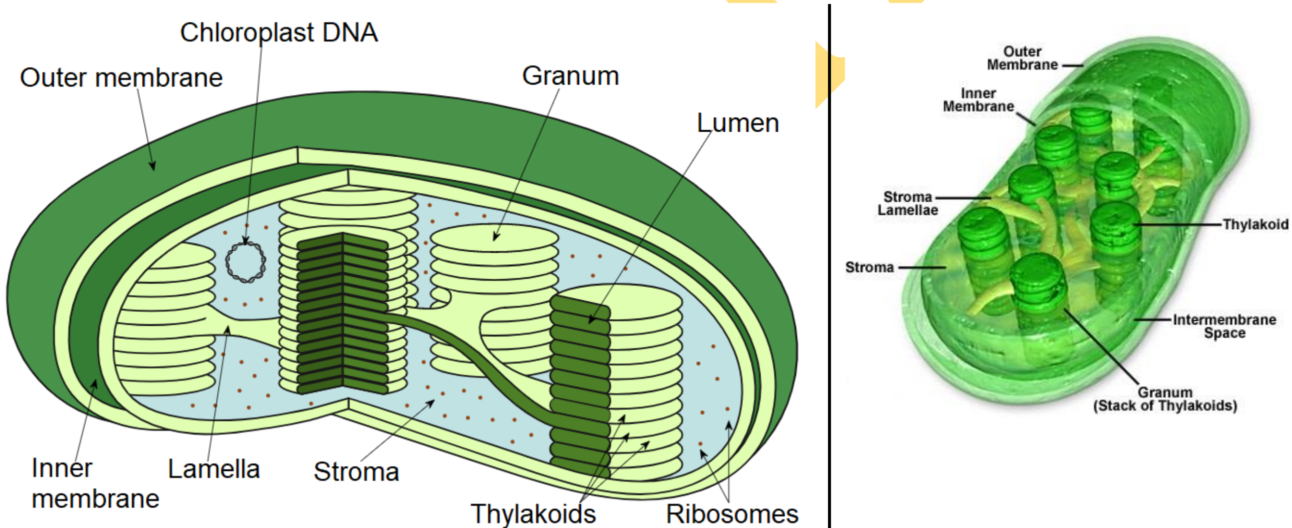
The chloroplast has **an inner and outer membrane with an empty intermediate space in between**. Inside the chloroplast are stacks of thylakoids, called grana, as well as stroma, the dense fluid inside of the chloroplast.

The stroma is semi gel like fluid with chloroplast DNA, 70S ribosomes, starch granules, lipid globules and thylakoid membrane system.

These thylakoids contain the chlorophyll that is necessary for the plant to go through photosynthesis.

They belong to the large group of organelles known as **plastids**. They are pigmented with a green pigment called chlorophyll.

The structure of the chloroplast



The main function of chloroplast is being a site for manufacture of food during photosynthesis.

Adaptations of chloroplast to its function

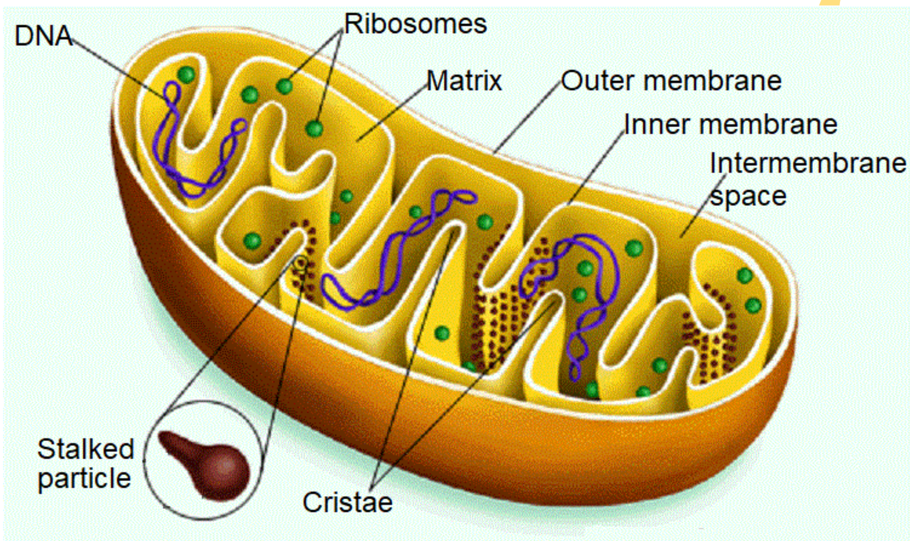
- Outer membrane is semi-permeable to regulate entry and exit of substances for maintaining internal chloroplast environment.
- Abundant light trapping pigments for photosynthesis.
- Abundant enzymes catalyze photosynthetic reactions in the stroma.
- Extensive network of thylakoid membranes increases surface area for photosynthesis.
- Narrow intermembrane space enables H^+ ion concentration gradient to be rapidly established for chemiosmosis to occur.
- Inner membrane contains molecules for electron transport pathway.
- DNA is present to act as genetic material for synthesis of some protein.
- Many ribosomes for protein synthesis to reduce on importing proteins from cytoplasm.

3. Mitochondria

Mitochondria have an inner and outer membrane, with an intermembrane space between them. The outer membrane contains proteins known as porins, which allow movement of ions into and out of the mitochondrion. The inner one is folded inwards to give rise to extensions called cristae and contains a variety of enzymes. The surfaces of the cristae have stalked granules along their length.

Mitochondrial matrix is fluid filled, with several enzymes, small sized ribosomes and circular DNA.

Transverse section of the mitochondria



Stalked particles/granules contain ATPase enzyme which increases surface area over which respiration occurs.

Adaptations of the mitochondrion to its function

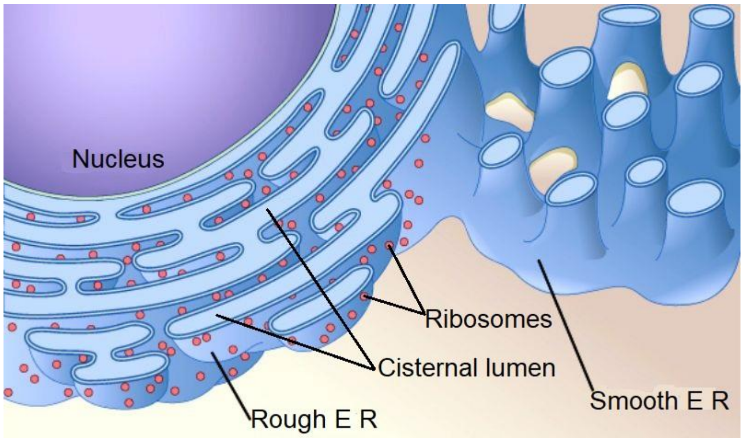
- Double membranes isolate the mitochondrion from interference by processes in the cytoplasm.
- Small size gives large surface area to volume ratio for rapid uptake/release of materials.
- Matrix contains enzymes of Krebs cycle.
- Inner membrane forms cristae to increase the surface area for electron transport chain.
- Inner membrane contains stalked particles that make ATP
- Narrow intermembrane space enables H^+ ion concentration gradient to be rapidly established for chemiosmosis to occur.
- Inner membrane contains molecules for electron transport pathway
- DNA is present to act as genetic material for synthesis of some proteins.
- Many ribosomes for protein synthesis to reduce on importing proteins from cytoplasm.

4. Endoplasmic reticulum (E. R):

The ER is the system of membranes found out on the nucleus forming a cytoplasmic skeleton. The ER is an extension of the outer nuclear membrane with which it is continuous. The membranes form a series of sheets which enclose flattened sacks called cisternae.

Where the membranes are lined with ribosomes; they are called rough endoplasmic reticulum (R.E.R). The RER is concerned with protein synthesis and it is most abundant in those cells which are rapidly growing or secrete enzymes.

In the same way, damage to a cell often results into increased formation in order to produce the proteins necessary for the cell repair.
Where the membranes lack ribosomes, they are known as smooth endoplasmic reticulum (S.E.R). The SER is concerned with lipid synthesis and is consequently in those cells producing lipid related secretions e.g., the sebaceous glands of the mammalian skin.



Functions of the ER

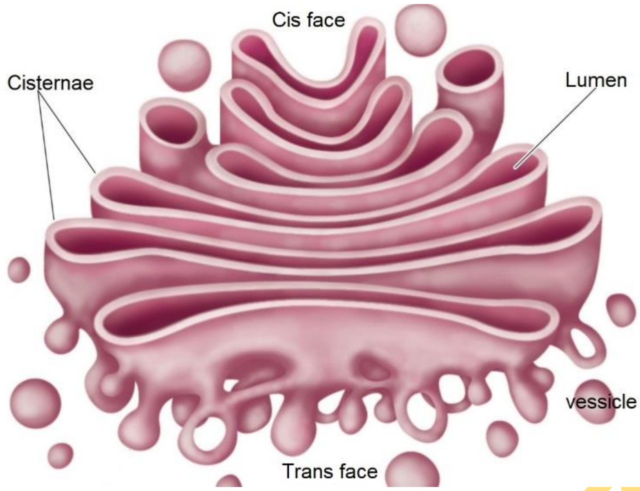
- Providing a large surface for chemical reactions.
- Providing a pathway for the transport of the materials in the cell.
- Producing proteins especially enzymes (RER).
- Producing lipids and steroids (SER).
- Collecting and storing synthesized materials.
- Providing a structural skeleton to maintain cellular shape. E.g., the SER of the rod cell of the eye retina.
- Synthesis and repair of membranes by producing cholesterol and phospholipids, (SER).

Adaptations of endoplasmic reticulum

- The interconnected network provides the cell with skeletal framework.
- Forming an extensive network increases the surface area for metabolic reactions e.g., protein synthesis at RER.
- The endoplasmic reticulum membrane compartmentalizes the cytoplasm (isolates lumen from cytosol), which enables transporting soluble and well packaged substances to their specific destinations.
- The endoplasmic reticulum membrane compartmentalization also prevents interference of different metabolic processes taking place in the cell at the same time.
- Contains a variety of enzymes for performing divergent roles in cell metabolism.
- The SER is modified into sarcoplasmic reticulum for storage and release of calcium ions during muscle contraction and relaxation.
- The membrane has a variety of proteins that offer unique properties including signal reception.
- The RER membrane has sites for attachment of many ribosomes for protein synthesis.

5. Golgi body:

Golgi body is made up of piles (stacks) of flattened sacs called **cisternae** (*singular*: **cisterna**) with vesicles budding (pinching) off at edges of sacs.
One cisterna is a flattened sac, with a lumen enclosed by a single membrane.
Between 4-8 cisternae pile up to form a stack which bends to form a semi-circle.
A cell may have 40 to 100 stacks. An individual stack of the cisternae is sometimes referred as **dictyosome**.
The cisternae carry structural proteins important for their maintenance as flattened membranes which stack upon each other.
The Golgi apparatus is more developed in secretory cells and neurons and is small in muscle cells. This suggests that the Golgi apparatus plays some role in the production of secretory materials.



Functions of the Golgi apparatus

- To modify, sort and package proteins that are made at the rough endoplasmic reticulum for secretion (export) or for use within the cell.
- Transport of lipid molecules around the cell.
- Formation of lysosomes containing hydrolytic enzymes.
- Formation of peroxisomes.
- In plant cells, Golgi produces vesicles that join to form cell plates during cell division.
- Secretory vesicles produced by Golgi apparatus contain a variety of important substances e.g., neurotransmitters, hormones, mucin, zymogen e.g., pepsinogen, etc.
- Fusion of Golgi vesicles with cell membrane maintains the membrane which is used to form phagocytic vacuoles and Pinocytic vesicles.

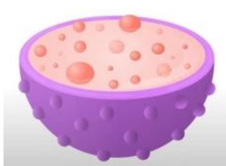
Note: Golgi complex is the cell's **"post office"** or **"shipping department"** where molecules are packaged, labelled and sent to different parts of the cell.

Adaptations of the Golgi apparatus

- Cisternae are enclosed by selectively permeable membranes, which isolate the inside cavity from cytosol for efficient functioning.
- Tubular structure enables transportation of soluble **protein** and **lipids** from the endoplasmic reticulum for modification.
- Variety of enzyme systems for modifying proteins by adding carbohydrates and phosphate by the process of **glycosylation** and **phosphorylation** respectively.
- Many cisternae increase the surface area for modifying synthesized macromolecules.

6. Lysosomes

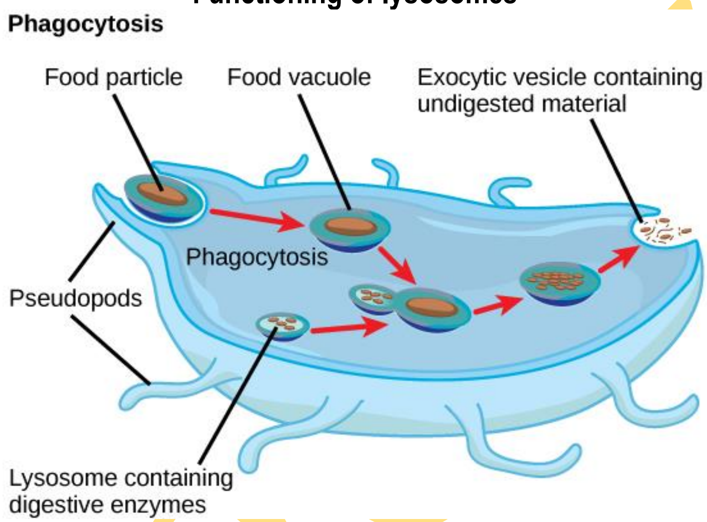
This is a simple spherical sac bounded by a single membrane and containing digestive enzymes (hydrolytic enzymes). It has no internal structures which are visible. The word lysosome comes from two words 'lysis' meaning splitting, 'soma' meaning body. Therefore, lysosomes are connected with the destruction of cells and their structures.
Lysosomes are bound by a single membrane and contain digestive hydrolytic enzymes like hydrolases in acid solutions. They isolate these enzymes from the remainder of the cell and in so doing they prevent them from acting upon other chemicals and organelles within the cell.



Functions of lysosomes

- They digest materials which the cell consumes from the environment. In case of white blood cells, the material may be bacteria. In protozoa it is the food which has been consumed by phagocytosis.
- They digest parts of the cell e.g. worn out organelles in a process called **autophagy**. A lysosome fuses with worn-out cellular components like mitochondrion to form autophagic vacuole in which digestion occurs by lysosomal enzymes into end products which leave by diffusion or with the aid of specialized transporters into cytoplasm while undigested materials (residual body) is released outside by exocytosis.
- After death of the cell, they are responsible for its complete breakdown a process called **autolysis.** Primary lysosome releases hydrolytic enzymes within a dead cell to digest the **whole** cell.
- They release enzymes outside the cell (exocytosis) in order to break down other cells e.g. in the re absorption of tad pole tails during frog metamorphosis.

Functioning of lysosomes



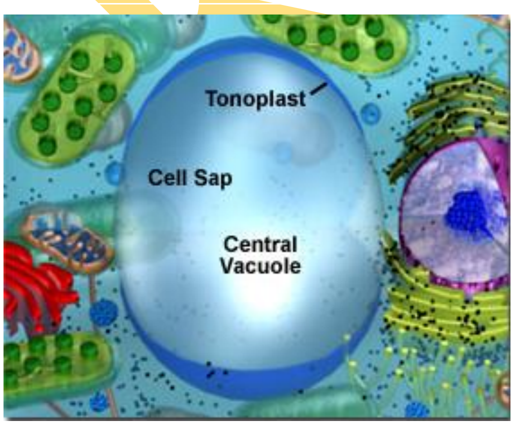
7. Microbodies (peroxisomes)

These are small roughly spherical organelles bounded by single membrane. They contain metabolic enzymes mainly catalase enzyme which catalyzes the breakdown of hydrogen peroxide which is a toxic bi-product of many chemical reactions within organisms.

Peroxides containing catalase are therefore more in metabolic reactions like those in the liver i.e.

$2H_2O_{2\,(aq)} \qquad 2H_2O_{(l)} + O_{2(g)}$

8. Vacuoles:



These are fluid filled sacs bounded by a single membrane. Within mature plant cells, there is usually one large central vacuole with a single membrane called a **tonoplast**.

The vacuole contains a solution of mineral salts, sugars, amino acids, wastes e.g., tannins and pigments like anthocyanin.

Functions of vacuoles

- Sugars and amino acids which act as temporary food stores are stored within the vacuole.
- It stores anthocyanin which is of many colours and therefore may colour the petals to attract pollinating insects or fruits to attract animals for dispersal.

- They are temporary stores of organic wastes e.g., tannins. They accumulate in vacuoles of cells and are removed during leaf fall.
- They contain hydrolytic enzymes therefore perform functions similar to those of lysosomes.
- They support herbaceous plants and woody plants by providing the osmotic system which creates turgidity.

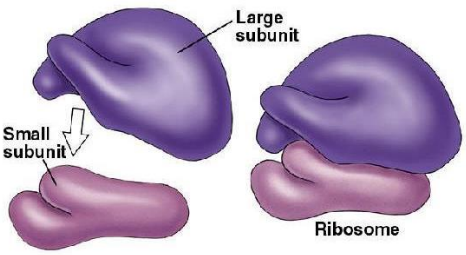
In animal cells, vacuoles are small, temporary and occur in large numbers. Common types include; food vacuoles, phagocytic vacuoles and contractile vacuoles which are important in osmoregulation in protozoa.

Non-membranous organelles

5. Ribosomes:

These are small, non-membranous particles/granules made up of a large (protein) and small subunit (rRNA), present in large numbers in all living cells. They are sites of protein synthesis.

Ribosomes on rough endoplasmic reticulum form proteins for export out of the cell e.g., hormones and enzymes.



Ribosomes that occur freely in the cytoplasm make proteins that remain within the cytoplasm e.g., dissolve in solution or form structural cytoplasmic elements.

Prokaryotes have 70S ribosomes (small subunit of 30S and large subunit of 50S) while Eukaryotes have mainly 80S ribosomes which are larger and more complex, each consisting of small (40S) and large (60S) subunit. (*S stands for the Svedberg unit for sedimentation velocity).*

The ribosomes share a core structure which is similar to all ribosomes despite differences in its size.

6. Storage granules:

Every cell contains a limited store of energy. The store may be in form of soluble material e.g. the sugar found in the vacuoles of plant cells. It may also occur in colloidal form as grains within the cell.

Starch grains occur within chloroplast and in the cytoplasm of plant cells. Starch may also be stored in specialized leucoplasts called amyloplasts.

Food energy is stored as glycogen in glycogen granules in the cytoplasm of animal cells.

Oil/lipid droplets are also found within the cytoplasm of both plant and animal cells.

7. Micro tubules:

These are slender unbranched tubes occurring throughout living cells. Their functions are:

- They provide an internal skeleton to the cells thereby determining their shape.
- They aid in transporting materials within cells by providing routes.
- They form a frame work along which cellulose cell wall in plants is laid.
- They are major components of the cilia and flagella where they contribute to their movement.
- They are found in spindle fibres during cell division and within centrioles from which spindles are formed.

8. Cilia and flagella:

These are almost identical except that cilium are shorter and more numerous than flagella.

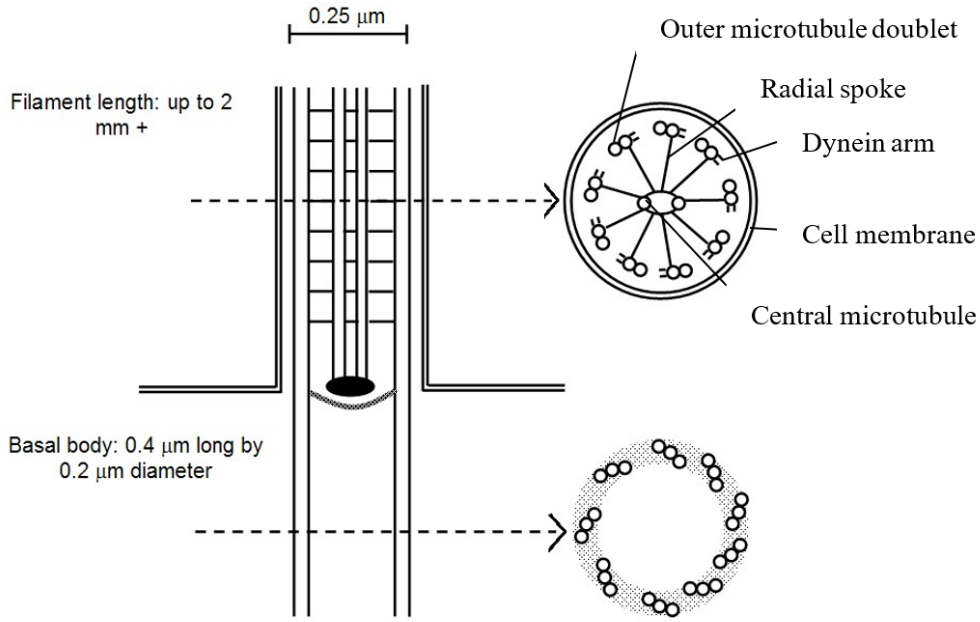
They are out-growth from cells and can beat either in one direction or both (cilia).

Their function is to move the whole organism e.g. cilia in paramecium or to move materials within an organism e.g. cilia lining the respiratory tract move mucus towards the throat.

Cross sections of a cilium shows that it contains a bundle of micro tubules which run longitudinally along its length arranged in a way that there are two in the center surrounded by a ring of 9 paired ones called doublets.

This arrangement is described as the 9+2 pattern.

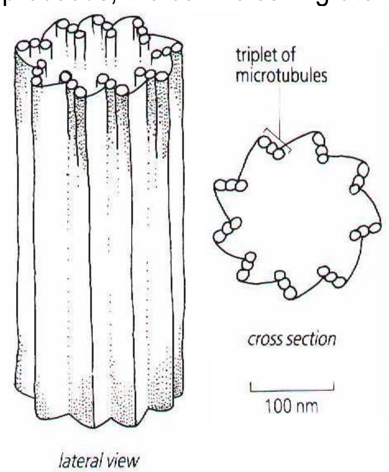
Longitudinal and transverse sections of the cilia/flagella



9. Centrioles:

These are small hollow cylinders about 0.3-0.5 µm long and about 0.2 µm in diameter. They occur in pairs in most animal cells. Each contains nine triplets of microtubules arranged in a ring in a **9+0 pattern**.

They arise from a distinct region of the cytoplasm called centrosome. Each centrosome has two centrioles. As cell division proceeds, the centrioles migrate to opposite poles of the cell where they synthesize the microtubules of the spindle.



10. Microfilaments:

These are very thin strands about 6 nm in diameter. They are made up of a protein called actin and a smaller proportion of myosin. These are the two proteins involved in muscle contraction. It means that microfilaments play a role in movement within cells and of the cell as a whole.

TOPICAL QUESTIONS FOR PAPER 2 (P530/2)

Qn. 1. (a) Distinguish between cell organelle and cytoplasmic inclusion (3 marks)

(b) Describe the fine structure of the following: (12 marks)

i Golgi complex

ii Nucleus

iii Mitochondrion

(c) How are the structures in (b) above suited for functioning? (5 marks)

Qn. 2. (a) What are the main ideas of the **cell theory**?

(b) Discuss possible exceptions to the **cell theory.**

(c) Explain how **surface area to volume ratio** and **nucleo-cytoplasmic ratio** influence cell size.

Qn. 3. (a) Describe the functioning of Golgi apparatus in animal cells.

(b) Explain the role of lysosomes in animal cells.

Qn. 4. By stating differences in structure and function, distinguish between

a) Rough endoplasmic reticulum and Golgi apparatus
b) Cell wall and cell membrane
c) Cilia and flagella

Qn. 5. Give an account of:

a) Fluid mosaic model of cell membrane structure (6 Marks)
b) The different functions of the membranes of cells. How do these functions relate to the structure of the membrane? (14 marks)

Qn. 6.

a) Describe the structure of plant cell wall (10 Marks)
b) Compare the structures of plant cell wall and plasma membrane (07 Marks)
c) How is the plant cell wall suited for functioning? (3 Marks)

Qn. 7.

a) Describe the structure and function of TWO eukaryotic membrane-bound organelles other than the nucleus.
b) Prokaryotic and eukaryotic cells have some non-membrane bound components in common. Describe the function of TWO of the following and discuss how each differs in prokaryotes and eukaryotes:
   i) DNA (ii) Cell wall (iii) Ribosomes.

Qn. 8. Membrane are important structural features of cells.

(a) Describe how membrane structure is related to the transport of materials across a membrane.

(b) Describe the role of membranes in the synthesis of ATP in either cellular respiration or photosynthesis.

Qn. 9. (a) Compare the structure of chloroplast and mitochondrion in relation to function.

(b) Eukaryotic cells have intracellular and extracellular components. State the functions of one named extracellular component.

Qn 10: explain the role of cell membranes in cells.