S5 BIOLOGY [MR ABIB AMIR] CONTINUED……

NUCLEUS

Nucleus is surrounded by a double membrane called the nuclear envelope. The outer membrane is continuous with the Rough endoplasmic reticulum (ER) covered with Ribosomes.

Nuclear envelope is perforated with nuclear pores. They allow exchange of substance between the nucleus and the cytoplasm for example messenger RNA and newly synthesized Ribosomes leave through these nuclear pores and allows entry of molecules needed for the manufacture of Ribosomes and DNA. The pore has a definite structure formed by fusion of the outer and inner membrane of the envelope. This controls the passage of molecules through.

The cytoplasm – like material within the nucleus is the nucleoplasm. It contains chromatins which is made up of coils of DNA bound to proteins called **Histones**. They form structures called **nucleosome**. The term chromatin means coloured material, implying that chromatins are easily stained for viewing under microscope. During cell division, the chromatin condenses to form the chromosomes. These stain more intensely and become visible.

Within the nucleus are one or two small round bodies each called a nucleolus. The densely staining core of the nucleolus is made up of the DNA from one or several chromosomes. They are the sites for the synthesis of Ribosome RNA and assemble Ribose.

FUNCTIONS OF THE NUCLEUS.

(i) Contains several DNA molecules located on the chromosomes. The DNA replicate and chromosomes are equally divided during cell division, ensuring that daughter cells have same composition of DNA and chromosomes as the parent cell.
(ii) Controls all activities taking place inside the cell.
(iii) The DNA in the nucleus carries the instructions for the synthesis of proteins.
(iv) The nucleolus in the nucleus is involved in the production of ribosomes.
(v) It divides during cell division for efficiency of the process.

ENDOPLASMIC RETICULUM (ER)

Endoplasmic reticulum (ER) consists of flattened, thin, double membrane bound sacs called **cisternae**. The cavities are interconnected and the lining membranes are continuous with the nuclear membrane. Attached to the matrix side of membranes are numerous ribosomes and such Endoplasmic reticulum are known as **Rough Endoplasmic reticulum.** The main function of the Rough ER is to Isolate and transport the proteins which have been synthesized in the Ribosomes. The proteins synthesized include digestive enzymes and hormones. The endoplasmic reticulum (ER) is thus a kind of intracellular transport system facilitating transport of most of material from one part of the cell to another.

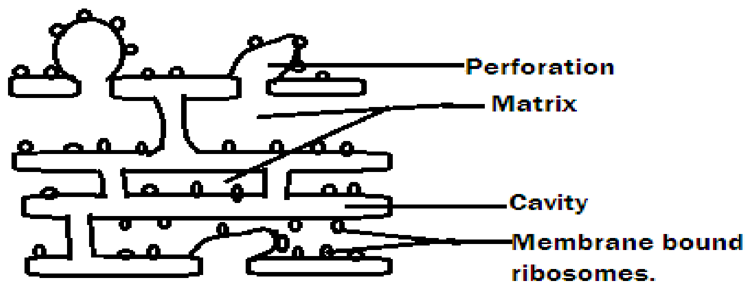
In certain parts of some cells the ER is not lined with Ribosomes and it is known as **smooth endoplasmic reticulum**. Smooth ER is not continuous with Rough ER and its cavities are tubular sacs. It is seen particularly in cells of the liver, gut and certain glands and is concerned with the synthesis and transport of lipids and steroids.

In rough ER, the proteins are transported through the cisternae usually when modified as it is transported e.g. it may be converted into glycoproteins. The proteinis then transported to the Golgi apparatus from where it can be secreted from the cell and passed on to other organelles in the same cell.
In the epithelium of the intestine, the smooth ER makes lipids from fatty acids and glycerol and passes them onto Golgi apparatus for export. Smooth ER also makes steroids; some steroids are hormones such as the corticosteroids made in the adrenal cortex and the sex hormones such as testosterone and oestrogen. In muscle cells, a specialized form of smooth ER called **sarcoplasmic reticulum** is present. They secrete calcium ions that will activate the process of muscle contraction.

FUNCTIONS OF ENDOPLASMIC RETCULUM (ER)

(i) Provide surface attachment to ribosomes which is the site for protein synthesis e.g. Rough ER.
(ii) Rough ER isolate and transports synthesized proteins such proteins include digestive enzymes and hormones.
(iii) Nuclear membrane is pierced by tiny pores which are continuous with the rough ER, thus providing a route by which materials might move from nucleus to the cytoplasm and vice versa.
(iv) Smooth ER synthesizes lipid and steroids and passes them to Golgi apparatus.
(v) In muscle cells a specialized form of smooth ER called sarcoplasmic reticulum secrete calcium ions that activate the process of muscular contractions.
(vi) Provide a large surface area for chemical reactions.
(vii) Collecting and storing synthesized material.
(viii) Providing a structural skeleton to maintain cellular shape e.g. Smooth ER of a rod cell from the retina of the eye.
(ix) produces Lysosomes.

STRUCTURE OF ROUGH ENDOPLASMIC RETICULUM



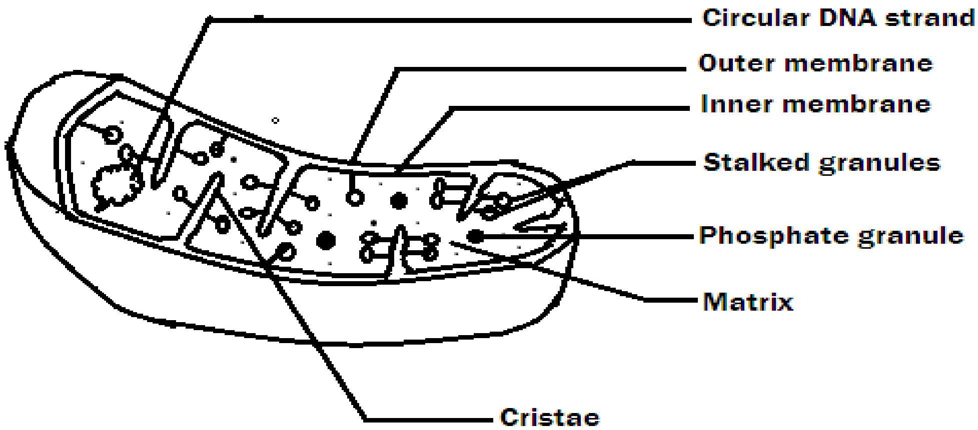
MITOCHONDRION

Are sausage shaped or cigar shaped, it is 1-2µm in size. Mitochondria range in shape from spherical to highly elongated. They are bounded by double membranes. the wall of a mitochondrion consists of two thin membranes separated by an extremely narrow fluid filled space. The inner membrane is slightly folded to form cristae which project into the interior.

Cristae increases the surface area for more ATP to be synthesized. The surface of these cristae has stalked granules along its length.

The watery matrix inside contains DNA, ribosome, calcium phosphate granules, enzymes (proteins) and lipids. Mitochondria are the site for most of the chemical reactions of respiration where energy in form of ATP is generated for the needs of the cell. Some reaction occurs in the matrix while others occur in the inner membrane. Highly active cells have higher demand for energy and therefore possess greater number of mitochondria than less active cells with low energy requirements. Mitochondria are often found tightly placed at the base of the motile tail of sperms contractile fibrils in muscle tissue and surface of cells in which active transport occurs. Mitochondria may be absent in mature red blood cells.

STRUCTURE OF A MITOCHONDRION



CHLOROPLAST.

Are about 3-10µm in diameter and are 4-10µm long. Chloroplasts can be cup shaped like those of chlamydomonas or biconvex discs. They are bound by a double membranes called chloroplast envelope (about 30µm thick) Chloroplast are surrounded by two membranes which form the chloroplast envelope. The outer membrane is a thin, smooth, continuous boundary, the inner membrane is folded into series of lamellae, extending throughout the organelle.

The matrix of the chloroplast is structureless, gel – like structure known as **Stroma**. A system of membranes that are stacked to form grana which are found within the stroma. Each granum is made up of between 2-100 closely flattened sacs called **thylakoids.** Thylakoids contain photosynthetic pigment such as chlorophyll. Some thylakoids have tubular extensions (intergrannal lamellae) which interconnect adjacent grana. Also present within the stroma are series of starch grains, smaller granules (Osmiophillic granules), small amount of DNA and small amount of oil droplets.

Chloroplasts are members of a group of organelles known as **plastids**. Plastids normally contain pigments such as chlorophyll and carotenoids. Photosynthesis occurs in chloroplasts in all green plants. In plants, chloroplasts are found in mesophyll cells of leaves and in the cells of the outer cortex of herbaceous (non-woody) aerial stems.

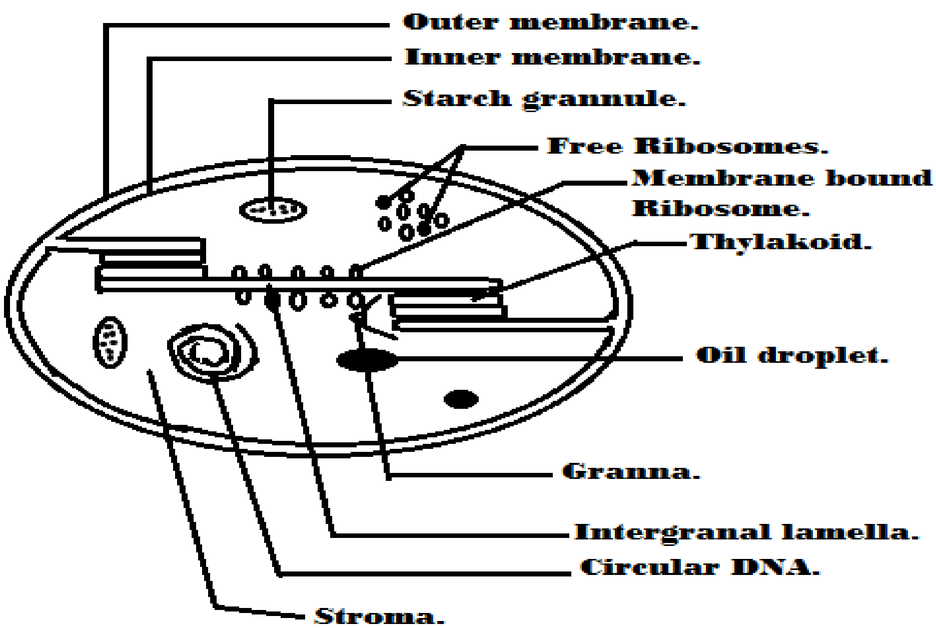
Other members of the plastid family include,

Leucoplasts (colourless plastids), common in storage organs such as roots and seeds and chloroplasts (coloured plastids) containing non-photosynthetic pigments, common in fruits and in flower petals and also in carrot tissue.

Amyloplasts

Are found widely in plant cells and is the major form of food storage and it contains starch.

DIAGRAM SHOWING STRUCTURE OF CHLOROPLASTS.



Assignement.

(a) Compare Mitochondrion and chloroplast.

(b) Describe features of the above named organelles suggesting that they have,

 (i) been derived from the prokaryotes.

 (ii) distinct from the prokaryotes.

GOLGI BODY.

It consists of stacks of flattened fluid filled cavities, Membrane – bound sacs called cisternae lined with smooth ER close to which are numerous vessels (small sacs) called **Golgi vessels**, these contain secretory granules. In Golgi body, there exists a complex system of interconnected tubules formed around the central stacks. At one end of the stack, new cisternae are constantly being formed by vesicles from the smooth endoplasmic reticulum (ER). Golgi body is formed by the fusion of vesicles which are pinched off from the cavities of the rough ER. The vesicles contain secretory molecules.

There is normally only one Golgi apparatus in each animal cell but in plant cells there may be a large number of stacks known as **dictyosomes**. Golgi body is well developed in secretory cells, neurones and is small in muscle cells. In general, it plays role in the production of secretory material.

Golgi apparatus functions as a processing and packaging structure. Golgi apparatus is present in all cells but is most prominent in those that are metabolically active. Golgi apparatus also collects proteins and lipids made in ER.
The main function of Golgi apparatus is for final synthesis of Glyco – proteins where it adds a carbohydrate part into synthesized proteins from rough endoplasmic reticulum (ER). This is supported by the experiments involving a radioatively labelled aminoacids, the steps of the experiment are shown below,

- The amino acids pass into the cell through the cell surface membrane by active transport, they are carried to the ribosomes.
- Mitochondria supplies energy in form of ATP for the active transport
- The amino acids are assembled into protein molecules. The proteins molecules enter into the rough ER
- Vesicles from rough endoplasmic reticulum carry protein to golgi-body.
- Protein move through golgi apparatus, where the carbohydrate is added to them to form glyco-proteins
- Secretory granule (golgi vesicles) budding off (pinched off) from golgi apparatus
- Mature secretory granule contains concentrated enzymes in an inactive form
- Secretory granules fuse with the cell surface membrane to release (glyco- proteins) inactive enzymes into pancreatic duct in the process called exocytosis

FUNCTIONS OF GOLGI BODY

(i) Transports and stores lipids and chemically modify materials within it.
(ii) In some cells, they secrete digestive enzymes e.g. in pancreas, specialized cells secrete the digestive enzymes of the pancreatic juice into the pancreatic duct.
(iii) It is also involved in the secretion of carbohydrates such as those involved in the synthesis of new cell walls by plants.
(iv) Important in formation of cell membrane and cell wall. Golgi vesicle are steered into position at the cell plate by microtubules. The membrane of the vesicles become the new cell surface membrane of the daughter cell while their content contribute to the middle lamella and new cell walls.
(v) Important in synthesis of glycoi-proteins in Golgi-apparatus. They add carbohydrate content to proteins to form Glyco-proteins.
(vi) Releases mucin, sticky slime and enzymes. Mucin is released by the Golgi body. The Golgi body in the leaf glands of some insectivorous plants such as sundews secrete a sticky slime and enzymes which trap and digest insects. The slime, wax, gum and mucilage secretions of many cells are released by the Golgi apparatus.
(vii) Formation of lysosomes

Note: Secretion of enzymes by pancreatic cells formation of new plant cell walls are good examples of division of labour, where many cell organelles combine to perform one function.

LYSOSOMES

The name lysosome is derived from two greek words ‘lysis’means splitting and ‘soma’ means body. Lysosomes are small spherical vesicles, 0.2-0.5μm in diameter and larger particularly in plant cells. The lysosome is bounded by a single membrane, but has no internal structures and contains a concentrated mixture of hydrolytic digestive enzymes. Lysosomes originate either from the Golgi apparatus or directly from the Endoplasmic reticulum. Lysosomes are found abundant in secretory cells and phagocytic white blood cells.

Lysosomes contain hydrolytic enzymes which are used in the dissolution and digestion of redundant structures or damaged macromolecules from within or outside the cell. Foods enclosed in vacuoles are digested by hydrolytic enzymes secreted by lysosome that fuse with the food vacuoles. Redundant cell organelles are enclosed in a membrane and broken down by enzymes released from lysosome, gland cells in some digestive organs package their digestive enzymes in lysosome before releasing them outside the membrane, when a cell dies its own lysosome release the enzymes that digest the remains of the cell in a process known as **autolysis**.

In plant cells, the large central vacuoles may act as lysosomes, In animals lysosomes are simply formed.

The enzymes contained within lysosomes are synthesized in rough ER and transported to the Golgi apparatus. Golgi vesicles containing the processed enzymes later bud off to form the lysosomes.

FUNCTIONS OF LYSOSOMES

(i) They digest harmful materials like bacteria in case of white blood cells, can also digest food that has been consumed by phagocytosis like in protozoa.

(ii) They digest parts of the cell such as a worn-out organelle. Lysosomes destroy worn out organelles within the cell. The lysosomes discharge hydrolytic enzymes into the sac, the enzymes breakdown the worn-out organelles such as mitochondria and the soluble products are absorbed into the surrounding cytoplasm.

(iii) They release their enzymes outside the cell (exocytosis) in order to breakdown other cells. For example, in the reabsorption of tadpole tails during metamorphosis and digestion of materials taken in by endocytosis.

(iv) Play role in activating enzymes into active forms that is secreted for example in secretion of the hormones Thyroxine. For example, they activate thyroglobulin into thyroxin.

(v) Unwanted structures within the cell are engulfed and digested within the lysosome. The process is called **Autophagy**. In this process the unwanted structures are first enclosed by a single membrane derived from smooth ER and then lysosome fuse with this structure to form an “autophagy vacuole” in which the unwanted material is digested.

This is part of the normal turnover of cytoplasmic organelles, old ones being replaced by the new ones.

(vi) Play role in the process of bone formation from the cartilage.

(vii) Facilitate the process of fertilization. Sperms contain special lysosomes called acrosome; it releases its enzymes which aid the sperm to penetrate the egg(ovum).

AUTOLYSIS

This is the self-digestion of a cell by releasing the hydrolytic enzymes from lysosomes within the cell. In such a situation, lysosomes are referred to as **"suicidal bags"**.

Autolysis can be quite a useful process in some cases, these include;

- Differentiation processes that occurs in the tissue when the tadpole tail is reabsorbed during metamorphosis.
- The uterus that has grown larger in size during pregnancy gradually returns to its normal size by self-digestion (autophagy) of many of the cells.
- It also continues after cells have died; this is the cause of food deterioration when unrefrigerated. Food deterioration may also occur as a result of certain lysosome diseases.
- Autolysis also occurs in muscles which are not exercised.

VACUOLES

A vacuole is a fluid-filled sac bounded by a single membrane. Animal cells contain relatively small vacuoles. These include phagocytic vacuoles, food vacuoles, autophagic vacuoles and contractile vacuoles. Plant cells such as mature parenchyma cells have a large central vacuole surrounded by a membrane called the tonoplast. The fluids contained in the vacuoles are known as the cell sap. It contains a solution of mineral salts, sugars, amino acids, wastes such as tannins, sometimes pigments such as anthocyanin, organic acids, oxygen and carbondioxide.

FUNCTIONS OF SAP VACUOLES.

(i) Provide bright colours to some plant organs such as the anthocyanins in the vacuole are of various colours and so may colour petals to attract pollinating insects and birds, or fruits to attract animals for dispersal.

(ii) They act as temporary stores for organic wastes such as tannins. These may accumulate in the vacuoles of leaf cells and are removed when the leaves fall.

(iii) They contain hydrolytic enzymes which can cause autolysis. and so perform functions similar to those of lysosomes. After cell death, the tonoplast and enzymes escape causing autolysis.

(iv) Are food reserves. Some of the dissolved substances such as mineral salts, sugars, and amino acids may act as food reserves which can be utilized by the cytoplasm when necessary.

(v) Leads to turgidity of cells since they absorb water by osmosis, the parenchyma cells in this case become turgid providing support to herbaceous plants and herbaceous parts of woody plants.

(vi) Waste products and certain secondary products of plant metabolism may accumulate in vacuoles. For example, crystals of waste calcium oxalate, alkaloids and tannins may offer protection from consumption by herbivores.

(vii) Latex, a milky liquid may accumulate in vacuoles as in dandelion stems. The latex of the rubber tree contains the chemicals needed for rubber synthesis and the latex of the opium poppy contains alkaloids such as morphine from which heroine is obtained.

MICRO- BODIES (PEROXISOME)

Micro bodies are small spherical membrane-bounded bodies which are between 0.5 and 1.5µm in diameter. They are slightly granular; they have no internal structure. They contain a number of metabolically important enzymes such as enzyme catalase. This enzyme catalase breaks down hydrogen peroxide to simple and harmless oxygen gas and water. Hydrogen peroxide is a potentially toxic by-product of many biochemical reactions within the cell. Peroxisome containing catalase is present in all plant and animal tissues in varying amounts. But more numerous in actively metabolizing cells like those of liver.