TOPIC:CELL STRUCTURE: LYSOSOMES AND CENTRIOLES

LECTURE NO:08
B.SC PART-II(SUB.)-GROUP A
DATE: 3RD APRIL 2020
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Lysosomes

General history of Lysosomes:-

Lysosome is an organelle which unlike other organelles, first became known through the biochemical studies and thereafter their morphological identifications were made. **Christian de Duve,** a Belgian cytologist and biochemist, in 1955 reported the presence of lysosomes in the cells by biochemical studies. Later on, **Novikoff** in 1956 observed these lysosomes as distinct cell organelles with the help of electron microscope.

Structure of Lysosomes:-

Lysosomes are round tiny bags filled with dense material rich in acid phosphatase (tissue dissolving enzymes) and other hydrolytic enzymes. They consist of two parts: (i) limiting membrane and (ii) inner dense mass.

Limiting membrane: This membrane is single and is composed of lipoprotein. Chemical structure is homologous with unit membrane of plasmalemma, consisting of bimolecular layer.

Inner dense mass: This enclosed mass may be solid or of very dense contents. Some lysosomes have a very dense outer zone and a less dense inner zone. Some others have cavities

or vacuoles within the inner granular material. Lysosomes are of various types and they help in intracellular digestion. Their contents vary with the stage of digestion.

Kinds of Lysosomes

There are four types of lysosomes: primary, secondary, residual bodies and cytolysosome or autophagosome.

Primary Lysosome (storage granules): It is a small sac like body. Its enzymatic contents are synthesized by ribosomes and accumulated in ER. From there, they enter the Golgi region, where acid phosphatase reaction takes place. The GERL region, i.e., acid phosphatase rich region of Golgi maturing face is thought to be involved in the production of lysosomes. The primary lysosome comprises only one type of enzyme or another.

Secondary Lysosome (digestive vacuole or heterophagosome): These are produced either from phagocytosis or pinocytosis of foreign material by the cell. Actually within the cell, after phagocytosis or pinocytosis, the foreign bodies or extra-cellular substances are enclosed within the membrane and these membranes bound structures are known as **phagosome or pinosomes.** These ultimately fuse with primary lysosomes, thus forming secondary lysosome. This body having engulfed material within membrane has also full complements of acid hydrolases (hydrolytic enzymes). The digested material of these lysosomes passes through the lysosomal membrane and is incorporated into the cell so that they may be reused in metabolic pathways.

Residual bodies*:* These are formed in case the digestion is incomplete. In some cells, such as Amoeba and other protozoa, these residual bodies are eliminated by defecation.

Hence, lysosomes **having undigested material or debris** are called residual bodies. These bodies are formed due to lack of certain enzymes in lysosomes. These are rejected from the cell by exocytosis and some time in certain cells these bodies remain in cells for long time causing ageing. These residual bodies also cause diseases in man such as **fever, hepatitis, polynephritis, hypertension, congested heart failure** etc. If the debris which is mostly lipid in nature may accumulate and condense into concentric lamella, it forms myelin figure.

Autophagic vacuole (cytolysosome or autophagosome): In this case, the lysosome **digests a part of cell** (e.g., mitochondria or portion of ER) by the process of autophagy. For example, liver cell shows numerous autophagosome during starvation among which remnants of mitochondria occur. This is a mechanism by which the cell can achieve degradation of its own constituents without irreparable damage (Fig. 1)

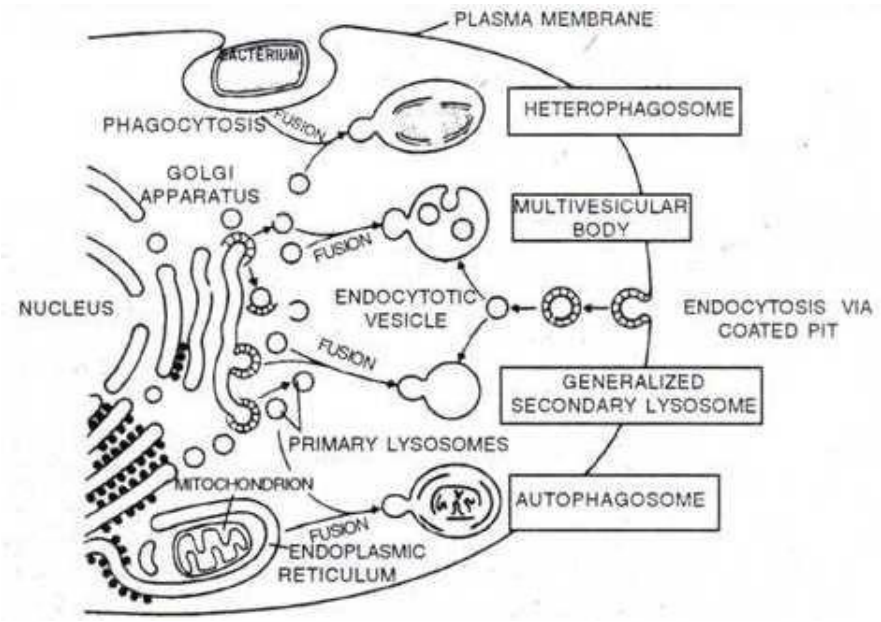

Fig.1: Formation of lysosomes and intracellular digestion in them

Chemical Nature of Lysosomes:-

Chemically lysosomes are defined as a body rich in **acid hydrolases**. Acid phosphatase has been found in many cells of plant roots, fungi, liver, kidney and endocrine glands. The lysosomal enzymes can break down all major biological macromolecules present in the cells or entering the cells from outside into their building block subunits by adding water. The common enzymes in the lysosomes are proteases, nucleases (deoxyribonuclease and ribonuclease), glycosidase, lipases, sulphatases and phosphatase, which hydrolyses proteins, nucleic acids, polysaccharides, lipids, organic sulphatases and organic phosphates respectively.

Functions of Lysosomes

Digestion of useful materials: Intracellular digestion is a regular feature in protozoans and in lower invertebrates such as sponges and coelenterates. In this process the organic substances (food particles) taken up by the cells in vacuoles (pinosomes or phagosome) from the environment are digested.

Digestion of harmful materials*:* The foreign particles, such as viruses, bacteria and toxic molecules, are disposed of by hydrolyzing them in certain leucocytes and macrophages. This is called natural defense of the body. This activity of lysosomes is characteristic of higher animals.

Digestion of unwanted materials: The dead cells and debris that accumulate at the sites of injury are destroyed in some white blood cells. This is called natural scavenging of the body.

Renewal of cells and organelles: The old worn out cells and cell organelles are broken down to make the component molecules available for formation of new cells and cell organelles. Thus, the lysosomes facilitate the turn-over of cells in normal tissues and of organelles in normal cells.

Feeding of starving animals*:* Food to a starving animal is provided by digesting the stored food materials (proteins, lipids and glycogen) and even the cells. This is called autophagy.

Autolysis*:* Autolysis caused by the lysosomal enzymes plays a role in normal developmental changes in both animals and plants. E.g., in the breakdown and absorption of tail during the metamorphosis of frog's tadpole. In autolysis, lysosome membrane ruptures and releases the enzymes into the surrounding cytoplasm. This kills and lyses the cell.

Aid in fertilization*:* The lysosome of sperms releases their enzymes to dissolve the egg membranes for the entry of the sperm into the ovum in fertilization. This is called extracellular digestion.

Importance of Lysosomes

As lysosomes store the hydrolyzing enzymes of the cell, they digest the incoming food materials and remove the foreign bodies and their organelles no longer required. Their membrane prevents the enzymes from escaping into the cytoplasm and destroying it.

Malfunctioning of lysosomes may lead to diseases. Abnormal rupturing of lysosomal membrane and release of enzymes may cause blood cancer, sunburn and genetic disorders. The degenerative changes in bones and joints associated with arthritis are suspected to be the result of abnormal release of enzymes

from the lysosomes of the bone cells or lymph cells into the extracellular fluid.

Centriole

General History of Centriole:-

Van Benden in 1880 discovered centrosome in cells of certain parasites of cephalopods.

Centrosome is the area of cytoplasm, often a clear zone, around the centriole. It is found lying in the center of the cell, near the nucleus, in the cytoplasm. In Metazoa, centrosome lies outside the nucleus, but in Protozoa it lies within the nucleus.

It is lacking in some plant cells. **T. Boveri** in 1888 described centrosome in detail.

The substance of centrosome also called kinoplasm consists of two parts:

- Smaller bodies or centrioles
- Surrounding mass or centrosphere

Structure of Centriole:-

The centrioles usually occur as paired hollow cylinders which are about 0.2µm in diameter and 0.3 to 0.5 µm in length. The two centrioles usually lie at right angles to each other.

The centriole is composed of nine sets of microtubules triplets arranged in a ring and embedded in a dense granular or amorphous, electron dense matrix (Fig. 2). There are no microtubules at the center of the ring giving the **"9+0"** pattern for the centriole. Each microtubule in a triplet is about 250Å wide.

The triplets are tilted in such a way that each forms an angle of about 30 to 40° to the circumference of the cylinder, with the A sub tubule of each set nearest the center of the ring. Membrane around the centrioles is absent. Sometimes a granular disc, called satellites, appears around the centriole.

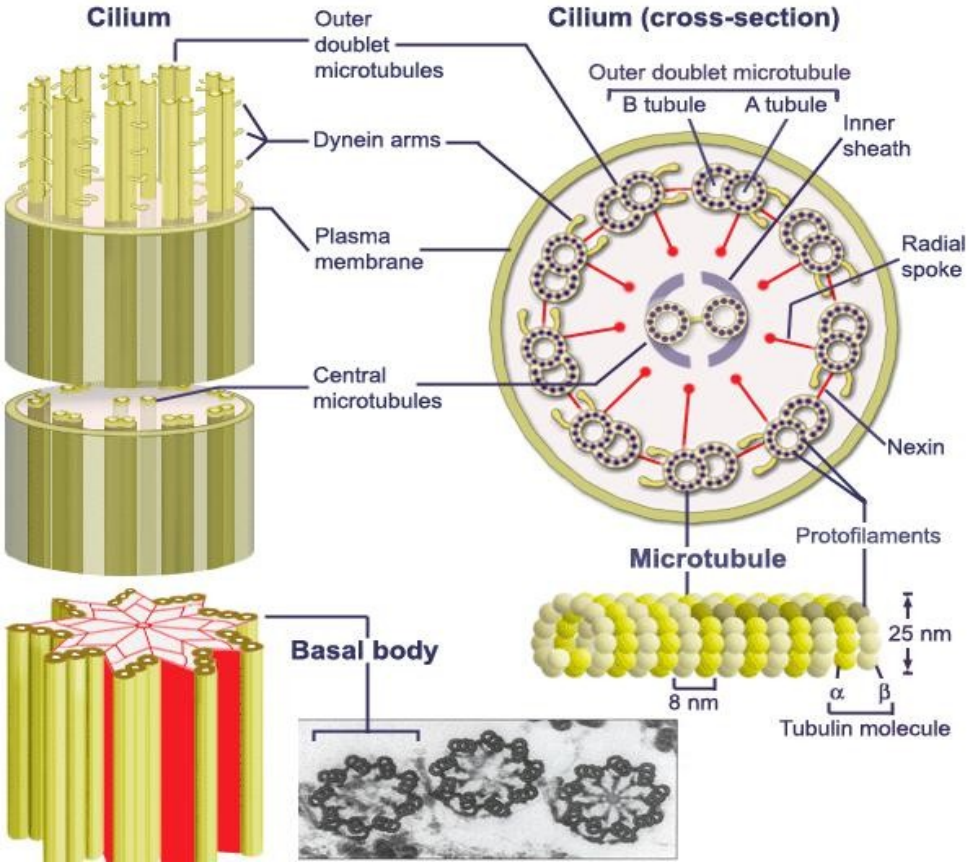

Fig. : T.S. Centriole, cilium and microtubule (showing faint 'cartwheel' pattern of fibrils)

All the triplets of centriole are similar and indistinguishable from one another. The three microtubules often called sub-tubules, of a triplet are named A, B and C, beginning from the inside of the cylinder. A dense strand called A-C linker, connects the A sub-tubule of each triplet to the C sub-tu bule of the adjacent triplet. These A-C linkers cause the tilt of the triplets from the radii of t he cylinder. A fine radial fiber or spoke joins each A sub-tubule to the central hub of the cylin der. Each radial

fiber has a dense thickenin g, the foot, near the A sub-tubule. This “cart-wheel” configuration though not always presents and when present it is often confined to the denser proximal end of the centriole. The C su b-tubules stop short of near upper ends and the peripheral tubules become doublet. B and C sub-tubules are C-shaped and their wall is co mpleted by adjacent sub-tubules. Only ‘ A’ sub-tubules are complete. The wall of ‘A’ sub-tubule is composed of 13 parallel proto-filaments which are made up of a row of α-β tubulin dimers (Fig. 3). A few proto-filaments are shared with the B-sub-tubule, which, in turn, sha res a few of its proto-filaments with the C sub-tubule (Fig. 4).

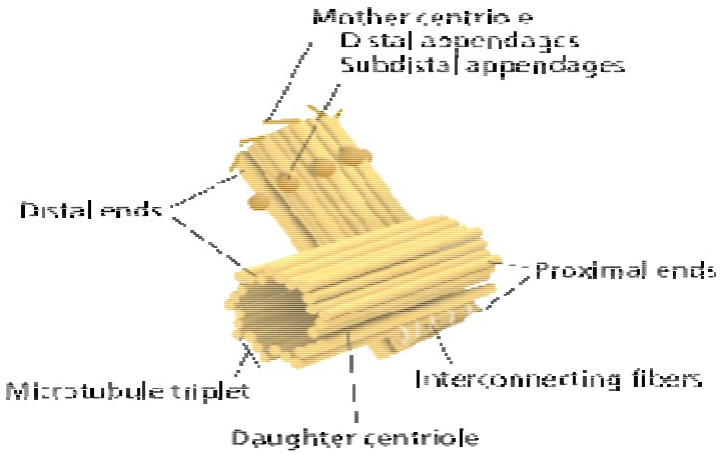

Fig. : A schematic view of centriole or basal body

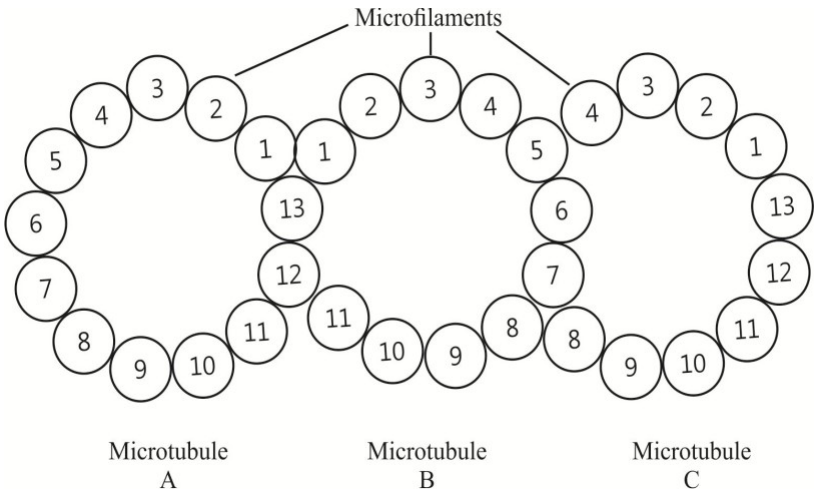

Fig.: Subunits of A, B and C microtubules in T.S.

Nine amorphous shap es of electron dense material with poorly defined outer limits are present around the centriole. These are called **pericentriolar satellites**.

Chemical Composition:-

The microtubule of the centriole is composed of a protein tubulin and some lipids having a high concentration of ATPase enzymes. They seem to contain RNA and a small DNA molecule. Proteins encoded by this DNA are presumably translated on cytosolic ribosomes and then incorporated into the centriole.

Functions of Centriole:-

The centriole serves the following functions:

They help in organizing spindle fibers and astral rays during mitosis and meiosis.

They provide basal bodies giving rise to cilia and flagella.

Pericentriolar material acts at the MTOC (microtubule-organizing centre) for the cytoplasmic microtubules.

Importance of Centriole:-

Centriole is involved in the **formation of spindle and astral rays** which are responsible for the chromosomal movements during cell division. Also, centrioles give rise to basal bodies (kinetosome) or cilia or flagella.

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