CELL BIOLOGY STRUCTURE AND FUNCTION OF LYSOSOMES

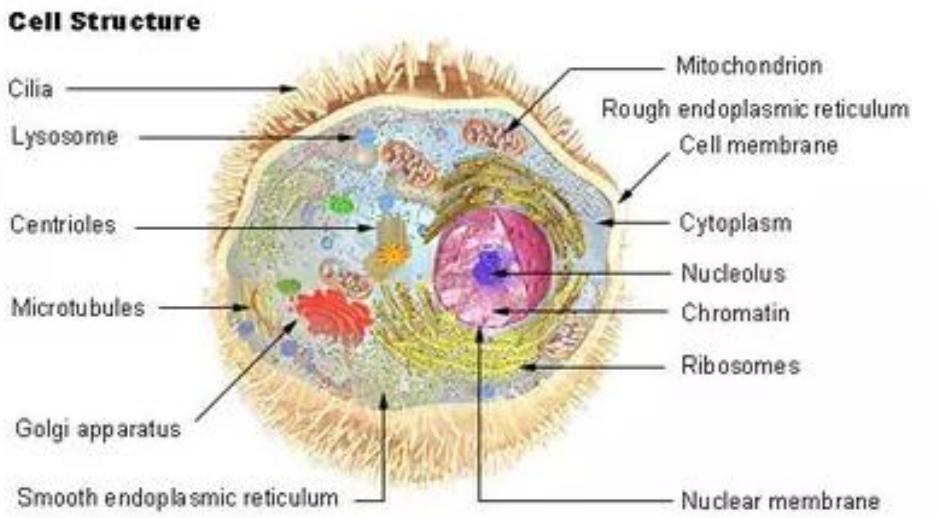
Dr Poonam kumari
Dept Of Zoology
Maharaja college, Ara
(B.Sc Part III PAPER VI Zoology Hons)

Lysosomes are the main digestive compartment of the cell. As such, they contain a variety of enzymes capable of degrading different types of biological material including nucleic acids, lipids and proteins among others.

They can be found in animal cells and some plant cells (occurring as vacuoles) and are capable of breaking down various types of macromolecules brought in to the cell to be degraded. Most of these macromolecules are either damaged or have completed their life cycle and are no longer useful.

Lysosomes also serve to break down cells once they die. While they can be found in almost all cells in animals (except red blood cells) they are particularly abundant in tissues/organs that are involved in high enzymatic reactions. These include such tissues/organs as the liver, kidney, macrophages and pancreas among a few others. Cells of these tissues/organs contain abundant lysosomes.

The name lysosome originated from Greek words **Lysis** (meaning destroy/dissolve) and **Soma** (meaning body).



Types of Lysosomes

There are two main types, these include:

Primary lysosomes - are formed from Golgi apparatus appearing as small vesicles. Although primary lysosomes are popular on Golgi apparatus, they also occur as granulocytes and monocytes. These lysosomes are surrounded by a single phospholipid layer and contain acid hydrolases.

The pH value of the acid in these vesicles is important in that its changes activate or deactivate the enzymes. Ultimately, most of the primary granules will fuse with phagosomes, which results in the formation of secondary lysosomes.

Secondary lysosomes - are formed when primary lysosomes fuse with phagosomes/pinosome (they are also referred to a endosomes). The fusion also causes the previously inactive enzymes to be activated and capable of digesting such biomolecules as nucleic acids and lipids among others.

Compared to primary lysosomes, secondary are larger in size and capable of releasing their content (enzymes) outside the cells where they degrade foreign material.

A majority of lysosomal enzymes function inside the acidic environment, which is why they are referred to a acid hydrolases. They contain about 45 enzymes that are grouped in to six main categories:

- **Nucleases** - Nucleases are important enzymes that hydrolyze nucleic acids. Nucleases are divided in to deoxyribonuclease (acts on DNA) and ribonuclease which hydrolyses RNA. Hydrolysis action on nucleic acids results in the production of sugars, nitrogen bases as well as phosphates.
- **Proteases** - Proteases includes enzymes like collagenase and peptidases that acts on proteins converting them to amino acids
- **Glycosidases** - Glycosidases like beta galactosidase act on the glycosidic bonds of polysaccharides converting polysaccharides to monosaccharides. For instance, the enzyme galactosidase acts on such bonds converting lactose to glucose and galactose.
- **Phosphatases** - Good examples of Phosphatases are acid phosphodiesterases. These are important enzymes that act on organic compounds releaing phosphate in the process. However, the compound has to have a phosphate group.
- **Lipases** - Lipases include esterases and phospholipiases that act on lipids to produce acids and alcohol

- **Sulphatases** - Sulphatases are enzymes that act on organic compounds to release sulphates

Lysosomes cannot digest themselves - Most of the proteins present in its membrane contain high amounts of carbohydrate-sugar groups. Because of the present of these groups, digestive enzymes are unable to digest the proteins present on the membrane.

Structure

Lysosomes are membrane-delimited organelles. This means that they are surrounded by a membrane that prevents its components from being released. This is particularly important given that uncontrolled release of the acidic fluid and enzymes can cause damage to the components of the cell. They also have a high concentration of protons, which results in pH value of less than 5.

The surrounding membrane is composed of integral proteins as well as a vacuolar-type H+ ATPase, highly glycosylated proteins and a number of transporters. Depending on the type of lysosome and their function, they also greatly vary in size (between 1 micrometer and several microns) and general shape.

They are less defined compared to other types of organelles. When viewed, they appear as cytoplasmic dense bodies that may be ovoid, spheric or tubular on occasion.

Function

The manner in which lysosomes function highly depends on the way the enzymes affect other materials outside and inside the cell. There are a number of processes through which lysosomes digest material.

1. Intracellular digestion:

The word lysosome is derived from (lyso lytic or digestive; and soma body) thus helping in digestion.

Pinocytic vacuoles formed as a result of absorption of fluid substance into cell or phagocytic vacuoles formed by absorption of solid particles into cell, carry protein material to lysosomal region.

These foreign proteins may undergo digestion within cell as a result of

endocytosis. Endocytosis includes the processes of phagocytosis (Gr., phagein, to eat), pinocytosis (Gr., pinein, to drink) and micropinocytosis.

Digestion of intracellular substances or autophagy:

Many cellular components, such as mitochondria, are constantly being removed from the cell by lysosomal system. Cytoplasmic organelles become surrounded by membranes of smooth endoplasmic reticulum, forming vacuoles, then lysosomal enzymes are discharged into autophagic vacuoles and the organelles are digested. Autophagy is a general property of eukaryotic cells. It is related to the normal renovation and turnover of cellular components.

The digestion of mitochondria or other cell structures, such as elements of ER, provides a source of energy for these cells. After the digestion of cell structure, the autophagic vacuoles may become residual bodies.

2. Removal of dead cells:

Hirsch and Cohn (1964) told that lysosomes help in the removal of dead cells in tissues such as white blood cells with engulfed bacterium in blood, cells in the outer layer of skin and mucous membrane linings of the body.

Lysosomal membrane ruptures in these cells, releasing enzymes into body of cell, so that whole cell may be digested. Lysosomes contain a sufficient complement of enzymes to digest most types of biological or organic materials and the digestive process (autolysis) occurs quite rapidly in dead cells. This process of tissue degeneration (necrosis) is due to this lysosomal activity.

3. Role in metamorphosis:

Recently lysosome's role has been discovered in the metamorphosis of frog. Disappearance of tail from tadpole larva of frog is due to lysosomal activity (action of cathepsins present in lysosomes) as described by Weber.

4. Help in protein synthesis:

Novikoff and Essner (1960) have suggested the possible role of lysosomes in protein synthesis. Recently, the author (Dr. Singh 1972), has correlated lysosomal activity with the protein synthesis. In liver and pancreas of some birds, lysosomes

seem to be more active and developed as reported by Singh (1972), showing possible relationship with cell metabolism.

5. Help in fertilization:

During fertilization, sperms head secrete some lysosomal enzymes which help in the penetration of sperm into vitelline layer of ovum. Acrosome contains protease and hyaluronidase and abundant acid phosphatase. Hyaluronidase disperse the cells around the oocyte and protease digests the zona pellucida making a channel through which sperm nucleus penetrates.

6. Role in osteogenesis:

It has been argued that formation of bone cells and also their destruction depends upon lysosomal activity. Likewise, ageing of cells and parthenogenetic development are related with the lysosome activity.

The osteoclasts (multinucleated cells) which remove bone, do so by the release of lysosomal enzymes which degrade the organic matrix. This process is activated by the parathyroid hormone.

7. Malfunctioning of lysosomes:

Lysosomal malfunction may lead to diseases, for example, when glycogen taken up by lysosomes is not digested (Pompe's disease). Ruptures of lysosomes in skin cells exposed to direct sun light leads to pathological changes following sunburn. The enzymes liberated by these lysosomes kill cells in the epidermis, causing blistering and later to 'peeling' of a layer of epidermis.

8. Autolysis in cartilage and bone tissue:

The excess of vitamin A causes cell poisoning. It disrupts the lysosomal membrane, causing release of enzymes into the cell and producing autolysis in cartilage and bone tissue.