LYSOSOMES

MBOTCC-10
Unit-I

M.Sc. Sem-III
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General Characteristics:

(i) Every eukaryotic cell has a group of intricately complex cytoplasmic organelles called lysosomes whose principal function is intracellular or extracellular digestion. They operate as a dynamic system of membrane flow and modification.

(ii) De Duve (1955) discovered this class of cellular particles by cell fractionation techniques which showed centrifugal properties intermediate between mitochondria and microsomes and had a high content of acid phosphatase and other hydrolytic enzymes.

(iii) Lysosomes were so names due to their lytic properties.

(iv) Some 50 hydrolases are known today which are able to digest biological substances.

(v) Lysosomes have been found both in animal and plant cells, as well as in protozoans.

However, lysosomes are not found in bacterial cells.

(vi) Lysosomes have an important property of their stability in living cells.

Enzymes contained in the lysosomes are not readily available to the substrate.

(vii) Latency of lysosomal enzymes is due to the presence of their surrounding membranes upon which their enzymes cannot act. The lysosomal membrane is resistant to the enzymes

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contained in them.

- The entire process of digestion is carried out intracellularly by the lysosomes (endocytosis).

- Under certain pathological conditions, lysosomal membrane may become labile and permit the exit of enzymes leading to catastrophic consequences to the cell.

(viii) Lysosomes are roughly spherical with an average diameter of 500nm. Their diameter may range from 50nm to several μm.

(ix) pH of lysosomal hydrolases varies from 3.5 to 5.0.

(x) Lysosomal enzymes are produced by rough ER and packaged within lysosomes by the Golgi apparatus.

Polymorphism of Lysosomes:

(i) Lysosomes exhibit a remarkable polymorphism regarding their size and irregularities of internal organization. As such, they are extremely dynamic structures.

(ii) Lysomes are surrounded by multivesicular bodies, smooth and coated vesicles, and dense bodies.

- This suggests the possibility of fusion and fission events between these structures.

(iii) Polymorphism of lysosomes is currently known to result from the association of primary lysosomes with the different materials that are phagocitized by the cell.

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(iv) At present, four types of lysosomes are recognized, of which the first is the primary lysosome, while the other three may be grouped together as secondary lysosomes.

(a) Primary Lysosome (Storage granule)

- It is a small body whose enzymatic content is synthesized by the ribosomes and accumulated in the ER.
- From these the enzymes penetrate into the Golgi region, in which the first acid phosphatase reaction takes place.
- Primary lysosome may be charged preferentially with one type of enzyme or another.
- It is only the secondary lysosome that the full complement of acid hydrolases is present.

(b) Secondary Lysosomes

(1) Heterophagosome (= Digestive Vacuole)

- This results from the phagocytosis or pinocytosis of foreign material by the cell.
- This body, which contains the engulfed material within a membrane, shows a positive phosphatase reaction which may be due to the association with a primary lysosome.
- The engulfed material is progressively digested by the hydrolytic enzymes, which have been incorporated into the lysosome.

(2) Residual Bodies

- They are formed if the digestion

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is incomplete.

- They may remain for a long time and may load the cell.

③ Autophasic Vacuole/Cytalysosome/Autophagosome

- This is a special case in which the lysosome conttains a part of the cell in the process of digestion (eg., a mitochondrion or portions of ER).

(v) Lysosomes regularly engulf bits of cytosol which is degraded by a mechanism called microautophagy.

- This is a mechanism in which the cell can achieve the degradation of its own constituents without irreparable damage.

Lysosomal Enzymes:

(i) As currently understood primary lysosomes are the secretion products of the cell which, like other secretions, are synthesized by ribosomes, enter the ER and reach the Golgi region for final packaging.

- Since by this mechanism a cell may produce different types of lysosomes, and many other secretion products, it is likely that there is a topological specificity in the ER-Golgi system. Thus different products must be dispersed through different channels of the intracellular membrane system.

(ii) Studies on the biosynthesis of lysosomal enzymes cathepsin and β-glucuronidase indicate the biogenesis of lysosomal enzymes on ribosomes bound to the ER.

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(iii) Lysosomal enzymes are discharged into the ER lumen using a signal peptide mechanism similar to that of secretory proteins.

(iv) The mechanism by which these protein are sorted out and routed toward the lysosomes is as yet unknown.

However, the terminal phosphorylation of mannose and attachment to a receptor inside the ER may play an important role.

Functions of Lysosomes:

(i) Lysosomal enzymes digest proteins into dipeptides and carbohydrates into monosaccharides.

- Some disaccharides (inulin, dextran, etc.) are not digested and remain in the lysosomes.

(ii) Through the process of autophagy, lysosomes are involved in the renovation and turnover of cellular components.

(iii) Lysosomes are active in the remodeling of tissues during the course of development in some animals.

(iv) Digestion of extracellular material involves the release of primary lysosomes by exocytosis.

(v) Degradation of bone is activated by vitamin A and parathyroid hormone.

(vi) In rheumatoid arthritis lysosomal enzymes erode cartilage.

Crinophagy is a process by which excess secretary granules are removed.

(vii) Acrosome of the spermatozoa, which develops in the Golgi, is a special lysosome.

(viii) Lysosomes of leukocytes (specific granules) and monocytes are essential in defense against bacteria and viruses.

(ix) There are about 20 congenital diseases called Storage diseases, in

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which there is accumulation of substances (e.g., glycogen, glycolipids) in lysosomes. These diseases are due to the lack of certain lysosomal enzymes.

(X) Lysosomes are also found in plant cells.
- In seedlings they are involved in the hydrolysis and removal of protein and starch during germination.

(xi) Primary lysosomes are coupled with an extracellular system that is the result of endocytosis.
- Phagocytosis and pinocytosis are two forms of endocytosis.

(fig. - below)

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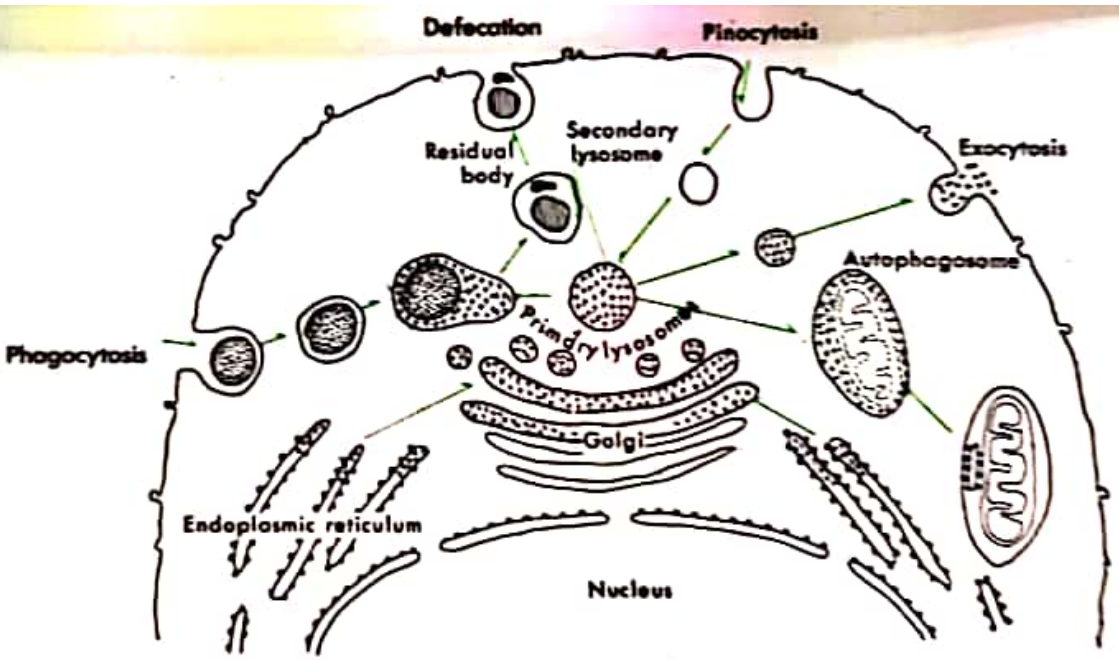

Fig. 10–3. Diagram representing the dynamic aspects of the lysosome system. Observe the relationships between the processes of phagocytosis, pinocytosis, exocytosis, and autophagy.