Lysosomes

Structure and Functions

E-Content for UG

ZOOLOGY; B.Sc.-I; Semester-II; ZOO CC-204

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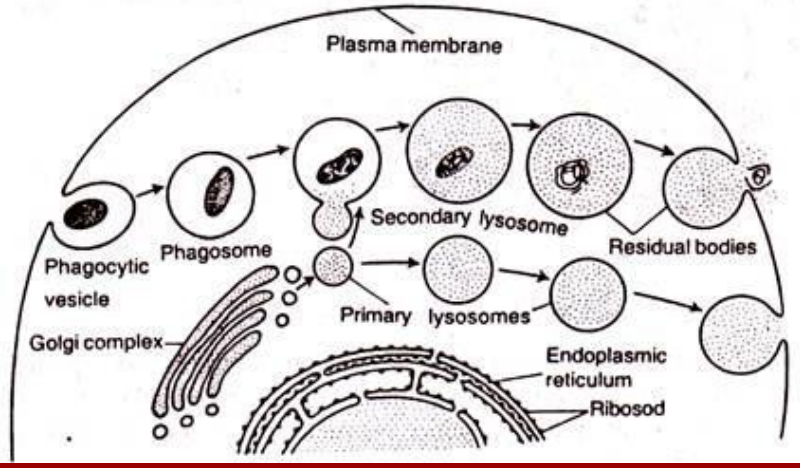

Introduction

- The Lysosomes (Gr., Lyso = digestive + soma = body) are tiny membrane bound cell organelles involved in intracellular digestion.

- They are popularly known as the **'suicidal bags'** of the cell due to their autolytic activities.

- Lysosomes have been described as the **'recycling centre'** because they free the metabolites from the worn out cell organelles by digesting them.

- In many organisms, lysosomes are involved in programmed cell deaths or Apoptosis.

- The term ‘Lysosomes’ was coined by de Duve (1955).
- Lysosomes are rich in hydrolytic enzymes and are bounded by a single membrane.
- These enzymes are capable of digestive nucleic acids, polysaccharides, fats and proteins.
- Most of the enzymes of lysosome work in acidic medium (pH around 5).
- Besides degradation of polymers into simple molecules, the lysosome is involved in various cell processes including secretion, plasma membrane repair, cell signalling and energy metabolism.
- Lysosomes occur in most of the cells but are absent in bacteria and mature mammalian erythrocytes.

- Few lysosomes occur in muscle cells or in acinar cells of pancreas.
- Leucocytes, especially granulocytes are rich in lysosomes. Their lysosomes are so large that they can be observed under the light microscope.
- These are also numerous in epithelial cells of absorptive, secretory and excretory organs (e.g. intestine, liver, kidney, etc.).
- They occur in abundance in the epithelial cells of lungs and uterus.
- Phagocytic cells and cells of reticuloendothelial system (e.g. bone marrow, spleen, and liver) are also rich in lysosomes.

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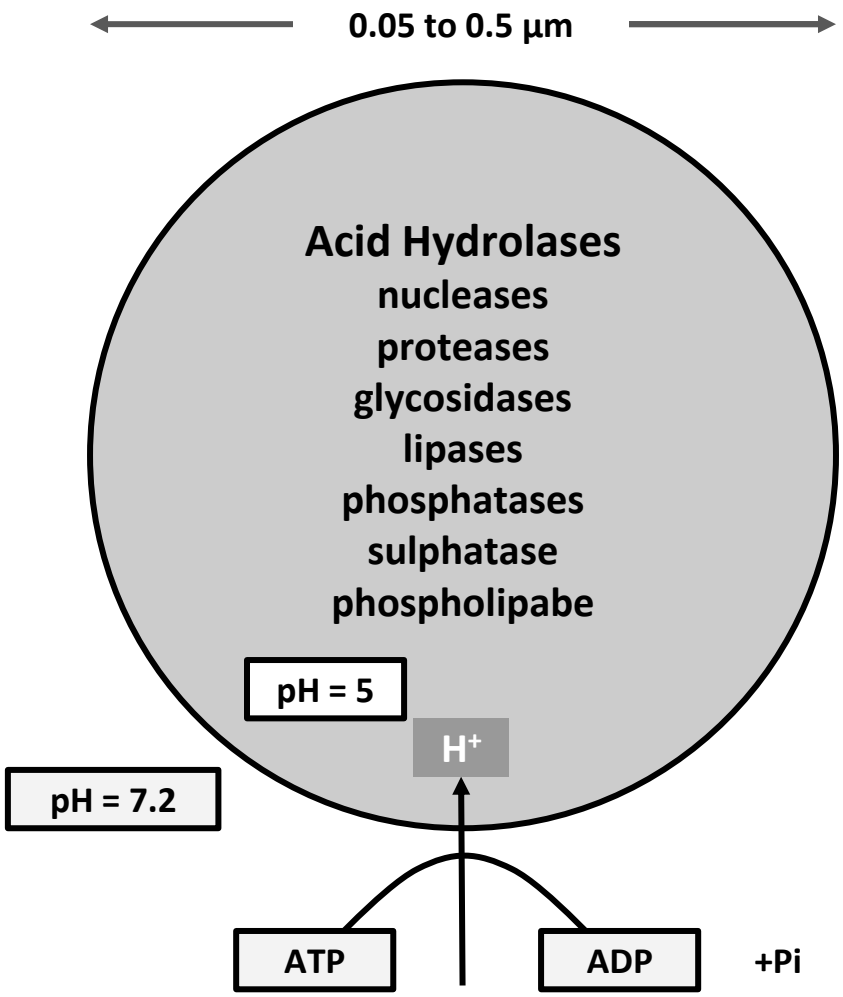
Structure of Lysosomes

- Lysosomes are spherical vacuolar structure which remain filled with dense hydrolytic enzymes and are bounded by single unit membranes.
- Their shape and density vary greatly.
- These are 0.05 to 0.5 μm in size. Their shape and size vary from cell to cell and time to time (i.e. they are polymorphic).

- The membrane of the lysosomes normally keeps the enzymes latent and out of the cytoplasmic matrix or cytosol, whose pH is about 7.2.
- The membrane is resistant to the enzymes (about 50 types of hydrolytic. enzymes) that it encloses. It is slightly thicker than that of mitochondria.
- The acid dependency of lysosomal enzymes protect the content of the cytosol (cytoplasmic matrix) against any damage even if leakage of lysosomal enzymes should occur.

- The acidification of lysosomal content depend on the ATP - dependent proton pump which is present in the membrane of the lysosomes and present in the membrane of the lysosomes and accumulates H^+ inside the organelle.
- Its membrane also contains transport protein that allows the final products of digestion of macromolecules to escape so that they can be either excreted or reutilized by the cell.
- Cholesterol, cortisone, cortisol and heparin act as membrane stabilizers for lysosomes, whereas steroids, sex hormones and lipid-soluble vitamins (A, D, E, and K) act as membrane labilisers.

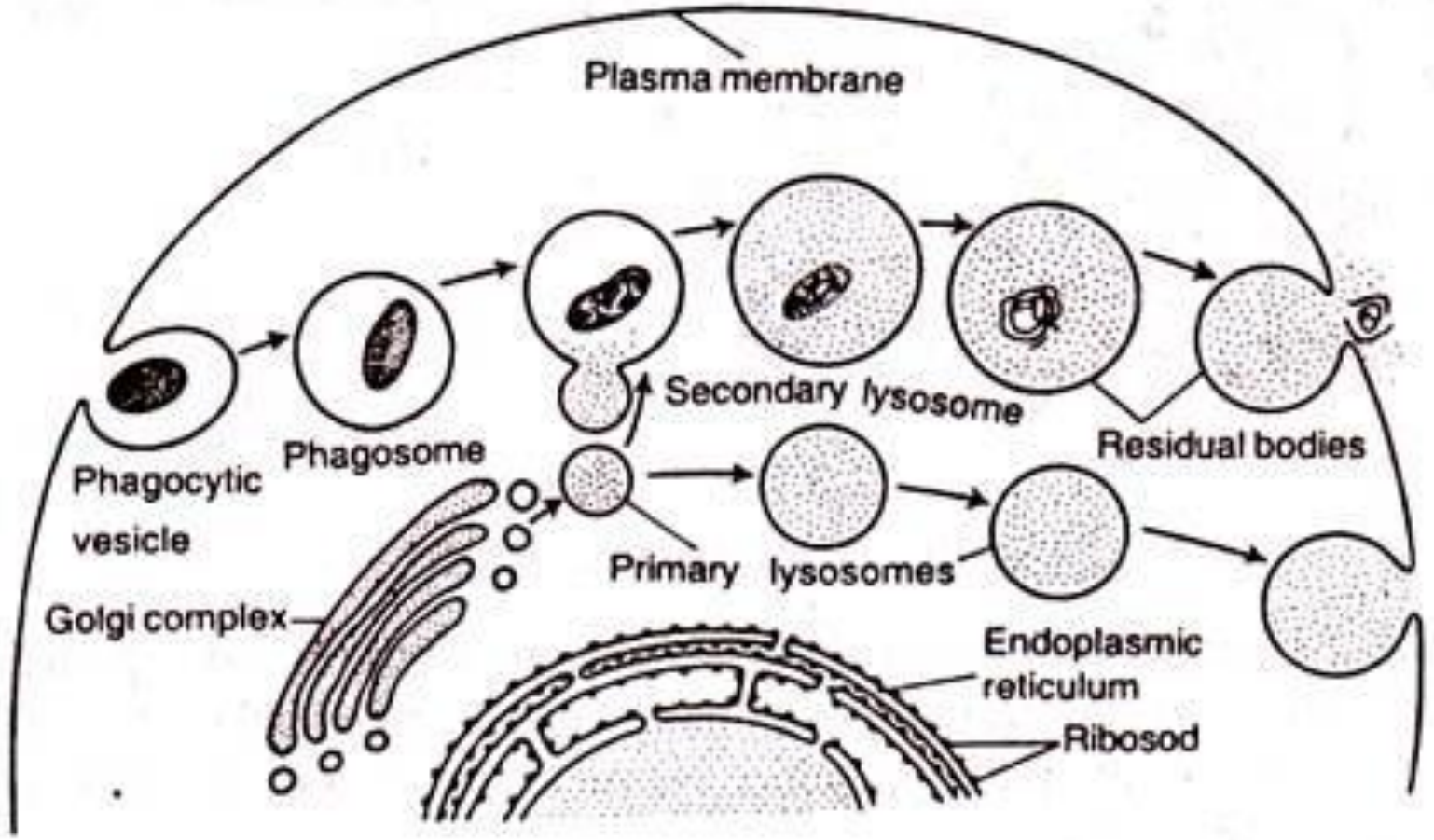


A Lysosome showing its various characteristics

Types of Lysosomes

Lysosomes show Polymorphism. The 4 different types of Lysosomes are:

1. **Primary Lysosomes**
2. **Secondary Lysosomes or Heterophagosomes**
3. **Residual Bodies**
4. **Autophagosomes**



Polymorphism in Lysosomes

1. Primary Lysosomes:

- These are also called storage granules, proto-lysosomes or virgin lysosomes.

- These are newly formed organelles and contain the degradative enzymes which have not participated in any digestive process.

2. Secondary Lysosomes or Heterophagosomes:

- These are also called heterophagic vacuoles, heterolysomes or phagolysosomes.
- These are formed by the fusion of primary lysosomes and engulfed materials brought into the cell by any of a variety of endocytic processes (e.g. pinocytosis, phagocytosis or receptor mediated endocytosis).
- The digestion of the engulfed substances takes place by the enzymatic activities of the hydrolytic enzymes of the secondary lysosomes.
- The digested material has low molecular weight and readily passes through the plasma membrane of the lysosomes to become a part of the matrix.

3. Residual Bodies:

- These are also called telolysosomes or dense bodies.
- These are formed due to incomplete digestion within the digestive vacuoles.
- The undigested material may be present in the form of whorls of membranes, grains, amorphous masses, ferritin, like or myelin fibres.
- Residual bodies are large, irregular in shape and are usually quite electron dense.
- Residual bodies may remain for a long time and may load the cell to result in their aging.

- For example, pigment inclusions (age pigments or lipofuscin granules) found in nerve cells, liver cells, heart cells and muscle cells of old animals may be due to accumulation of residual bodies.
- The primary Lysosomes originates from the Golgi apparatus.
- Malfunctioning of lysosomes cause a large number of diseases in humans such as Tay-Sachs disease Nieman-Pick disease, Farber's disease, Hunter's syndrome, Hurler syndrome, Scheic syndrome, Sanfilippo syndrome, Ponpe disease, I-cell disease, Rheumatoid arthritis, Silicosis, Asbestosis, etc.

4. Autophagosomes:

- They are also called Autophagic vacuole, cytolysosomes or Autolysosomes.
- Primary lysosomes are able to digest their own cell organelle/ intracellular structures including mitochondria, ribosomes, peroxisomes and glycogen granules.
- Such auto digestion, called autophagy of cellular organelles is a normal event during cell growth and repair and is especially prevalent in differentiating and de-differentiating tissues (e.g. cells undergoing programmed death during metamorphosis or regeneration) and tissue under stress.

- Lysosomes also engulf bits of cytosol which is degraded term Digestive Vacuoles is used to describe the organelle at the later stage (i.e. heterophagosome or autophagosome.

On the basis of morphology, their contents and functions, lysosomes are divided into following four forms:

Table: Polymorphism in lysosome

(i) Primary lysosomes	These are small, vesicle-like newly formed structures produced from the Golgi apparatus at *trans* face. Primary lysosomes contain inactive enzymes.
(ii) Secondary lysosomes	These are also called **heterophagosomes** or **disgestive vacuoles**, which are formed when phagosomes fuse with already existing primary lysosomes. These contain the enzymes against the material to be digested.
(iii) Residual bodies	These are formed from digestive and **autophagic vacuoles** which contain only undigested materials. Residual bodies pass outwardly, come in contact with plasmalemma and throw their contents to the outside through ephagy or exocytosis.
(iv) Autophagic vacuoles	They are formed by union of many primary lysosomes around old or dead organelles, surround them with vacuolar membrane and digest them by autolysis or autodigestion.

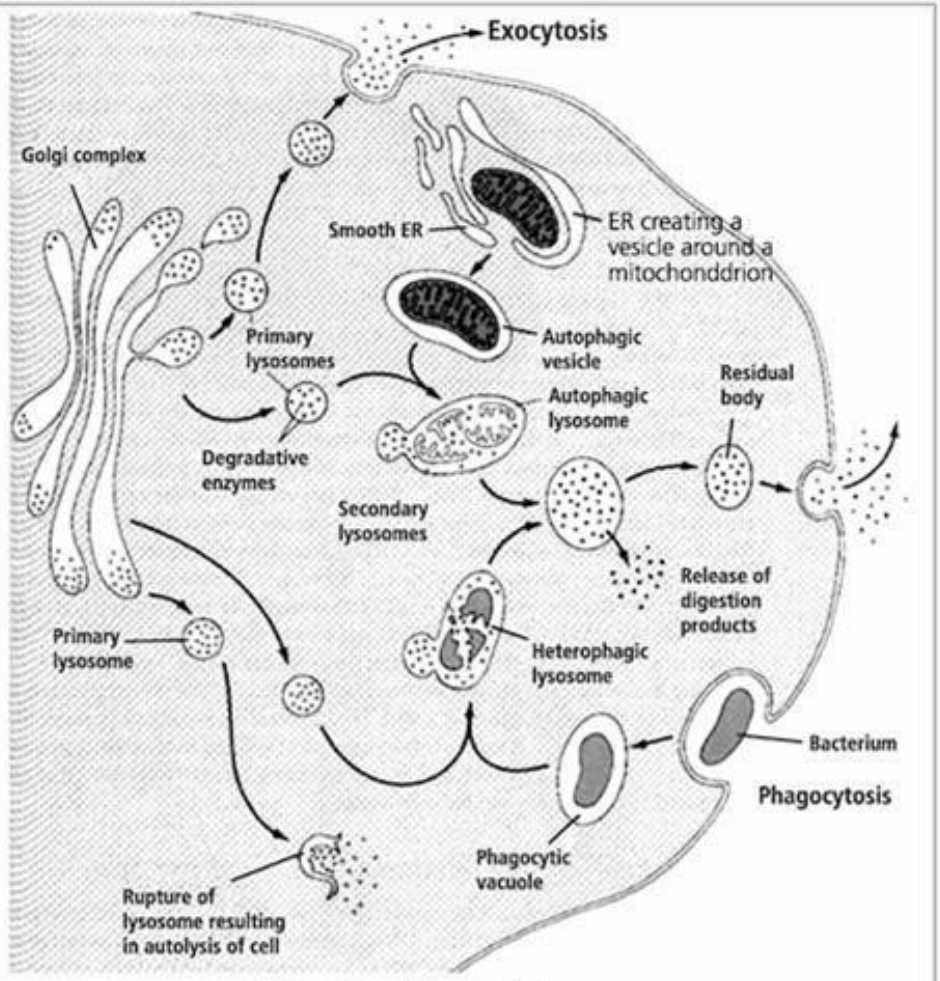


Fig.: Functions of lysosome

Functions of Lysosomes

The important functions of lysosomes are as follows -

1. **Digestion of large extracellular particles**
    - The lysosomes digest the food contents of the phagosomes or pinosomes.
    - The lysosomes of leucocytes enable the latter to devour the foreign proteins, bacteria, and viruses.

1. **Digestion of intracellular substances**
    - During the starvation, the lysosomes digest the stored food contents vix. Proteins, lipids and carbohydrates (glycogen) of the cytoplasm and supply to the cell necessary amount of energy.

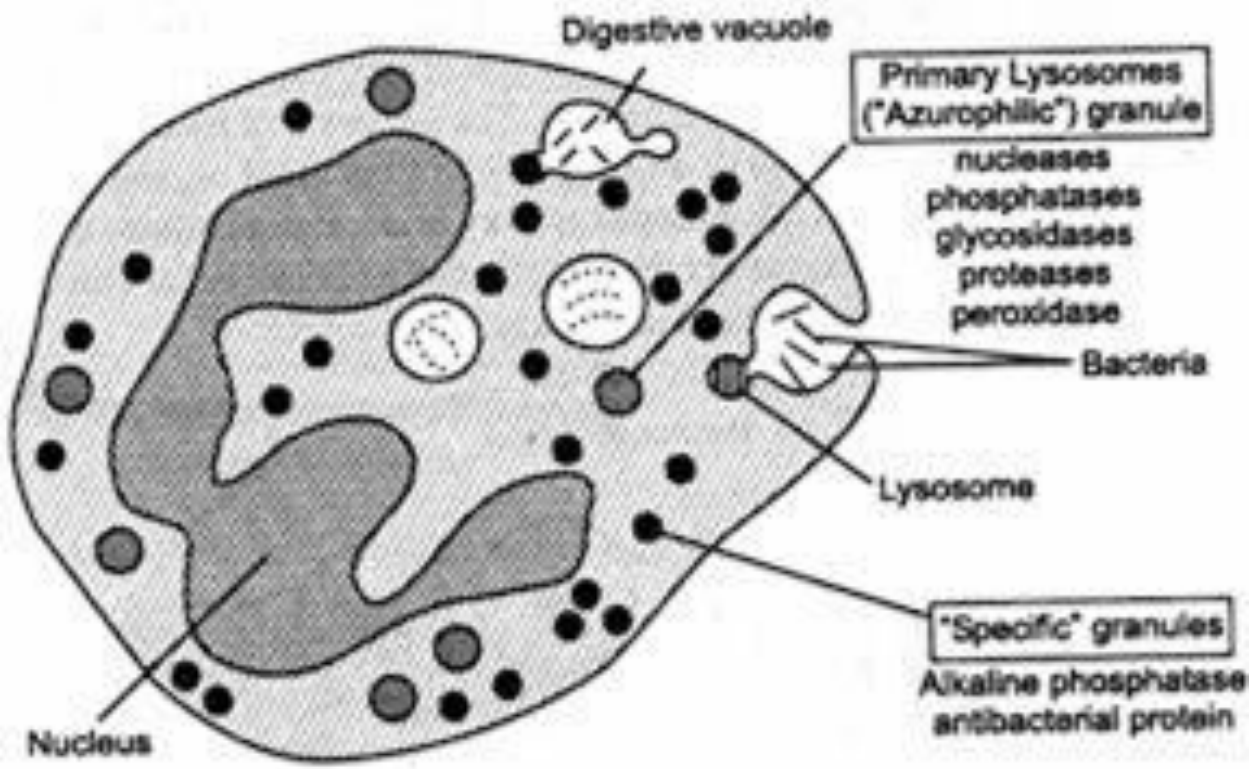


Fig 3: A white blood cell ingesting and digesting bacteria

3. Autolysis

- In certain pathological conditions the lysosomes start to digest the various organelles of the cells and this process is known as autolysis or cellular autophagy.
- When a cell dies, the lysosome's membrane ruptures and enzymes are liberated.
- These enzymes digest are liberated.
- These enzymes digest the dead cells.
- In the process of metamorphosis of amphibians many embryonic tissues, e.g. gills, fins, tails, etc. are digested by the lysosomes and utilized by the other cells.

4. Extracellular Digestion:

- The lysosome of certain cells, such as sperms, discharge their enzymes outside the cell during the process of fertilization.
- The lysosomal enzymes digest the limiting membrane of the ovum and form penetration path in ovum for the sperms.
- Acid hydrolases are released from osteoclasts and break down bone for the reabsorption; these cells also secrete lactic acid which makes the local pH enough for optimal enzyme activity.

- Likewise, preceding ossification (bone formation) fibroblasts release cathepsin D enzyme to break down the connective tissue.
- Similarly cathepsins help to release the thyroid hormones - T3 and T4 from their storage form - Thyroglobulins, in the thyroid gland.