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Lysosomes

Lysosomes are membrane bound tiny bags filled with digestive enzymes. They are concerned with intracellular digestion. They were discovered by **de Dave** in 1955.

- A lysosome is a **lytic body**. It is capable of lysis.
- *Lyso* means **digestive**, *soma* means **body**.
- It can destroy the cell in which it releases its enzymes. Hence, it is often called **suicidal bag**.
- As the lysosome digests the components of the cells, it is often referred to as the **digestive tract of the cell** (**de Duve**, 1963).
- It is a **cell organelle**.
- Lysosomes were first named as **pericanalicular bodies** because of their location. They are renamed as **lysosomes** by **De Duve** in 1955.

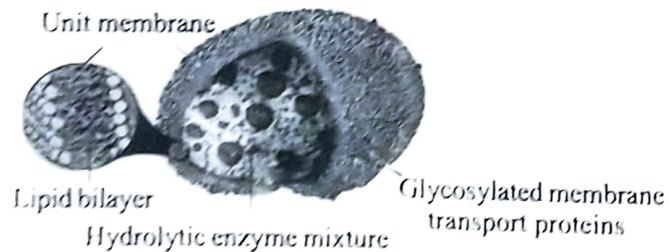


Fig 10.1: Anatomy of Lysosome.

- Lysosomes occur in most animal cells and in a few plant cells. They are most abundant in cells which are related with **enzymatic reactions** such as liver cells, pancreatic cells, kidney cells, spleen cells, leucocytes, etc.
- Lysosomes are usually **spherical** in shape; but they are irregular in certain meristematic cells of roots.
- The size of the lysosomes usually ranges from 0.2 micron to 0.8 micron in diameter, but may be exceptionally large as 8 microns in mammalian kidney cells and leucocytes.
- Lysosomes are round dense bodies filled with large number of dense granules having **hydrolytic enzymes** and **acid phosphatases**.
- The lysosomes are bounded by a **single layered membrane** in contrast to the double-layered membranes of other organelles. It is a **membrane** like that of plasma membrane. It is made up of **proteins** and **lipids**. Proteins in the lysosome membrane are glycosylated with sugar residues.
- The interior of some lysosomes is uniformly solid while others have very dense outer zone and a less dense inner zone.



Fig.10.2: Lysosomes.

- Lysosomes are **polymorphic** structures because their contents vary with the stages of digestion. On this basis, the lysosomes can be differentiated into four types. They are the following:
 - 1. Primary Lysosomes:** These are small **sac-like** structures enclosing enzymes synthesized by the Golgi body or endoplasmic reticulum. Since they store enzymes, they are also said to be **storage granules**. The enzymes present in primary lysosomes are **acid hydrolases**.
 - 2. Secondary Lysosomes (Digestive Vacuoles):** These are formed by the fusion of primary lysosomes with **phagosomes**. They contain engulfed materials and enzymes. The materials are progressively digested by the enzymes.

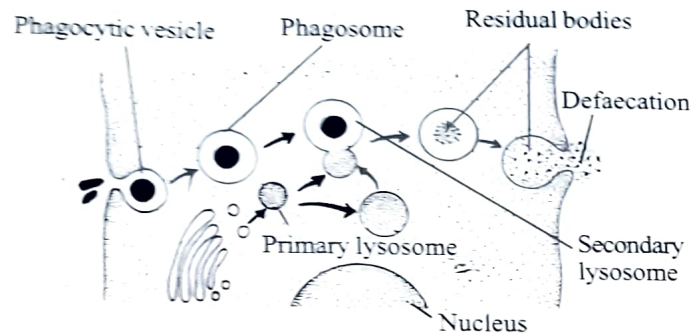


Fig.10.3: Polymorphism of lysosomes.

3. Residual Body: The secondary lysosomes with undigested wastes are called **residual lysosomes**. The digested materials are diffused into the cell cytoplasm through the lysosomal membrane.

4. Autophagic Vacuoles: Autophagic vacuoles are also called **autophagosomes**. These are special type of lysosomes, which are formed when the cells feed on their own intracellular organelles such as mitochondrion, endoplasmic reticulum, etc. and they digest them ultimately. This happens only during starvation. This process is called **microautophagy**.

Chemistry

Lysosomes contain a wide variety of enzymes. About 50 enzymes have been isolated. The enzymes are enclosed by the unit membrane. All enzymes are **acid hydrolases**. Oxidative enzymes are completely absent from lysosomes. These enzymes remain inactive inside the lysosomes. When the membrane is punctured, all enzymes are released and become active. The following are the enzymes located inside the lysosomes:

- | | |
|---------------------------|------------------------|
| 1. Acid ribonuclease | 8. Collagenase |
| 2. Acid deoxyribonuclease | 9. Peptidase |
| 3. Acid phosphatase | 10. Beta-galactosidase |
| 4. Acid phosphodiesterase | 11. Beta-glucuronidase |
| 5. Esterase | 12. Alpha-mannosidase |
| 6. Phospholipase | 13. Alpha-glucosidase |
| 7. Cathepsin | 14. Sulphatase |

The lysosomal enzymes are collectively called **hydrolases**. The hydrolases bring about the cleavage of substrates by the addition of a water molecule (hydrolysis) called **acid hydrolases**.

Most of the lysosomal enzymes function in the acid medium. Hence they are called **acid hydrolases**.

The lysosomes contain about 50 hydrolytic enzymes. A single lysosome may not contain all the enzymes.

The lysosomal enzymes are classified into six main types. They are following

1. Nucleases
2. Phosphatases
3. Sulphatases
4. Lipases
5. Proteases
6. Glycosidases

1. Nucleases

Nucleases act on **nucleic acids**. They hydrolyze nucleic acids into nucleotides.

The nucleases are of two types, namely **ribonuclease** and **deoxyribonuclease**. Ribonuclease acts on **RNA** and deoxyribonuclease acts on **DNA**.



2. Phosphatases

Phosphatases hydrolyze phosphate compounds. Phosphatases include **acid phosphatases** and **acid phosphodiesterases**.

3. Sulphatases

Sulphatases break down sulphate esters into fragments.

4. Lipases

Lipases hydrolyze lipids into **fatty acids** and **glycerol**. They include esterases and phospholipases.

5. Proteases

Proteases hydrolyze proteins into amino acids. Proteases include **cathepsin**, **collagenase** and **peptidases**.

6. Glycosidases

Glycosidases hydrolyze polysaccharides into monosaccharides. They include β -galactosidase, β -glucuronidase, **mannosidase**, α -glucosidase, etc.

Origin

Several possibilities have been suggested regarding the origin of lysosomes. The origin of lysosomes depends on the tissues in which they are located or on their function in a specific cell.

1. Extracellular Origin

Lysosomes may be the vacuoles formed from the plasma membrane by pinocytosis. Inside the cytoplasm, these vacuoles obtain enzymatic activities and become changed into lysosomes.

2. Origin from the Golgi

The accumulation of secretory products inside the vacuoles of Golgi leads to the formation of lysosomes. The lysosomal membranes are derived from the Golgi membrane.

3. Origin from Endoplasmic Reticulum

Novikof (1965) has shown that lysosomes directly originate from the granular endoplasmic reticulum.

Functions of Lysosomes

The lysosomes have the following functions:

1. Heterophagy

Heterophagy is the lysosomal digestion of foreign materials. It is an **intracellular digestion**. In heterophagy, the cells digest the foreign or extracellular food materials. These food materials are taken into the cells by endocytosis such as **phagocytosis** or **pinocytosis**. The food materials are enclosed in vesicles called **phagosomes** or **pinosomes**. These vesicles move towards lysosomes and fuse with the primary lysosome to form a digestive vacuole called **secondary lysosome**. The vacuole now moves to the plasma membrane. The enzymes of lysosomes digest the food materials in the digestive vacuole. The digested food materials diffuse into the cytoplasm

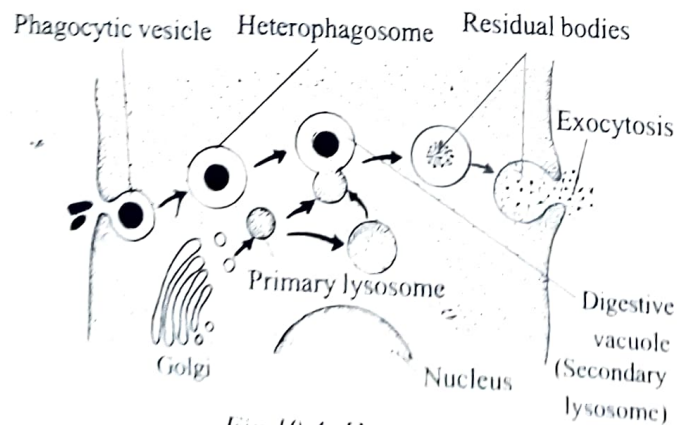


Fig. 10.4: Heterophagy.

through membrane of digestive vacuole. The waste materials in the digestive vacuole are expelled out by exocytosis. This vacuole fuses with the plasma membrane so that its content is discharged out.

2. Autophagy

Autophagy refers to the lysosomal digestion of own cell components. (*Auto* = self; *phagy* = eating). It is an **intracellular digestion**.

In autophagy, the cell organelles, worn out cells, dead cells, cell debris and stored food materials are digested by the lysosomes.

In autophagy, the organelle to be digested, is enclosed by a membrane called **isolation membrane**. The isolation membrane is derived from endoplasmic reticulum or Golgi body.

The vesicle formed in this way is called an **isolation body**. The isolation body fuses with the lysosome to form an **autophagic vesicle**. The digested particles diffuse into the cytoplasm and are utilized by the cell for the metabolic activities.

Menstruation is caused by the autophagy of uterine epithelium.

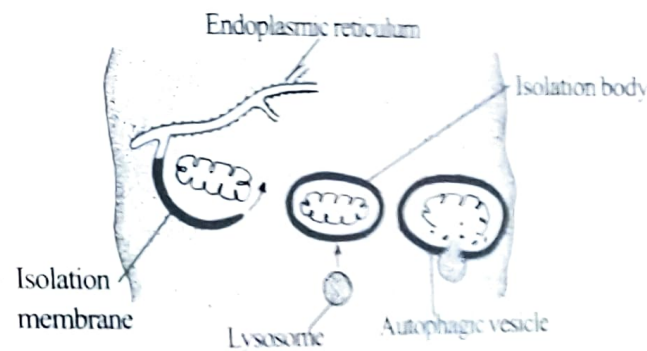


Fig. 10.5: Autophagy Lysosome digests a mitochondrion

3. Autolysis

Autolysis refers to the digestion of own cells by the lysosomes. *Auto* means 'self' and *lysis* means 'digestion'. It is **self digestion**. It is an **intracellular digestion**.

In autolysis, the lysosome digests its own cell. Hence autolysis is also called **cellular autophagy**.

In this process, the lysosome ruptures inside its cell and the released enzymes digest and degrade the cell. As lysosome kills its own cell, it is called **suicidal bag**.

Lysosomes in Plant Cells

Lysosomes are absent from plant cells. However, plant cells contain membrane bound vesicles containing enzymes. They are the following:

1. *Spherosomes*
2. *Aleurone grains*
3. *Vacuoles*

1. Spherosomes

Spherosomes are membrane bound spherical protein particles found in plant cells. They originate from endoplasmic reticulum. They synthesize lipids and the

lipids are stored in them.

In maize root tips and tobacco endosperm tissue, the spherosomes are rich in hydrolytic enzymes.

2. Aleurone Grains (Fig.10.4)

Aleurone grains are membrane bound spherical protein particles found in plant cells. They are found in the cells of endosperm and cotyledons of seeds. They are formed during seed ripening and disappear in the early stages of germination. They are derived from endoplasmic reticulum.

They store proteins and phosphates in the form of *phytin*.

The aleurone grains of pea-seeds contain a wide range of hydrolytic enzymes such as *protease* and *phosphatase*. These enzymes mobilize proteins and phosphates during germination.

3. Vacuoles

Vacuoles are spherical membrane-bound vesicles. They are derived from endoplasmic reticulum. They contain a clear viscous fluid. They may store food particles, essential oils, alkaloids, etc.