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Subject - Zoology

B.SC -1st year Semester – II
Paper – II: Cell Biology

UNIT- 2
Topic- 2.4 Lysosome: Structure, polymorphism and functions

Presented By

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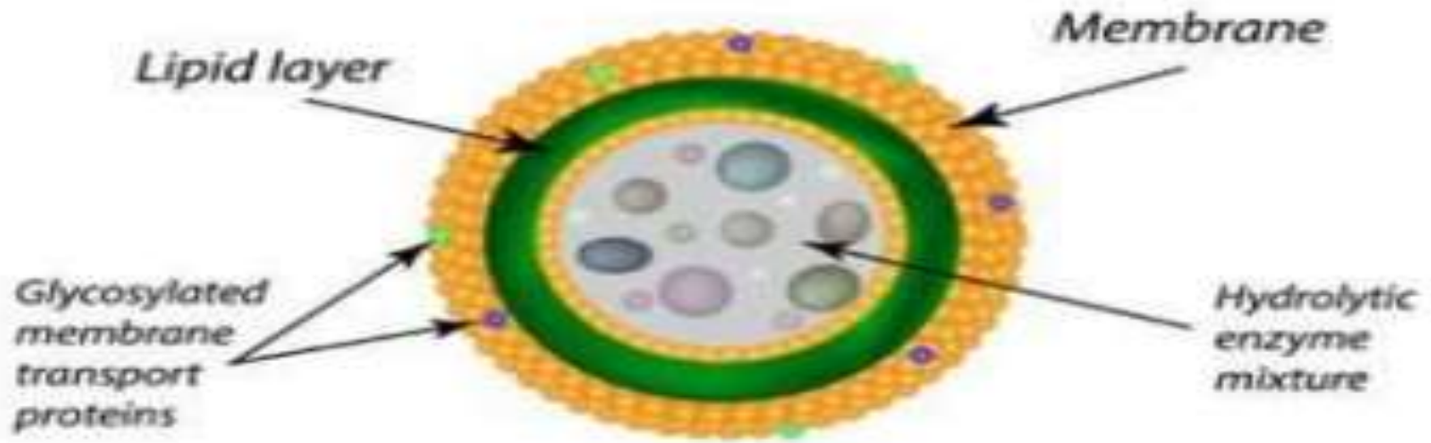
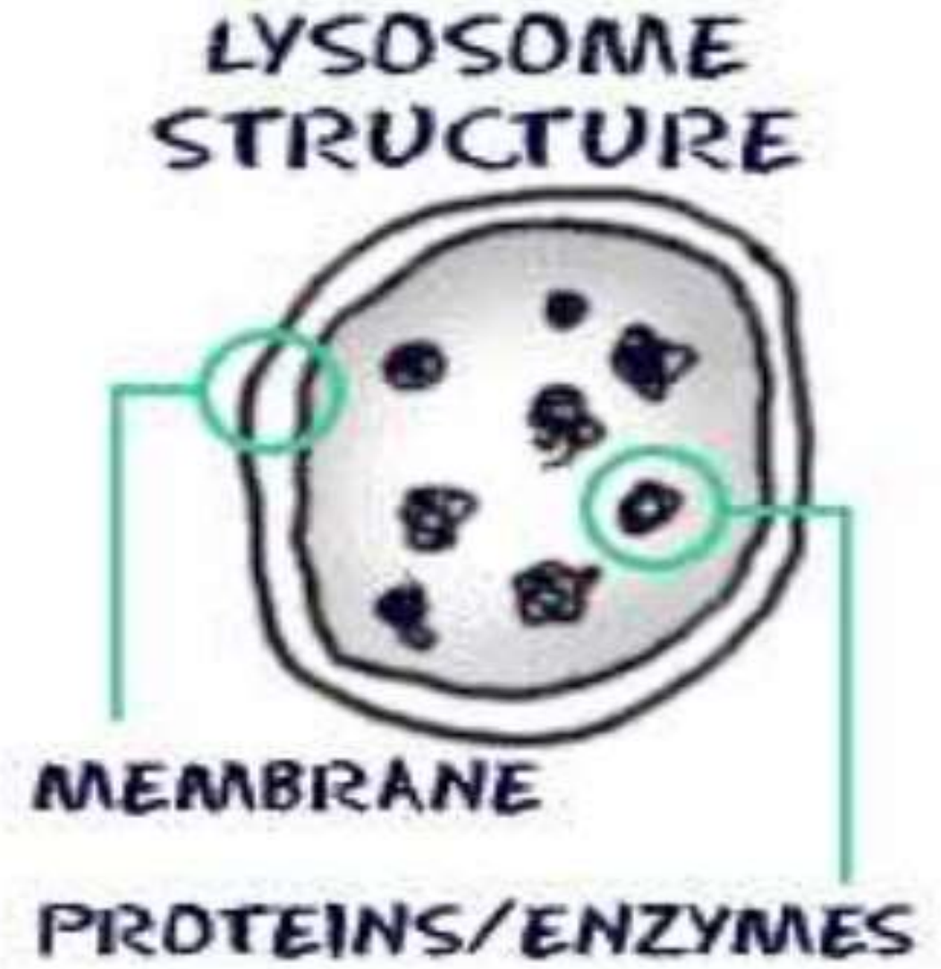
LYSOSOMES


Lysosome
Membrane
Lipid layer
Glycosylated membrane transport proteins
Hydrolytic enzyme mixture

Introduction

- Lysosomes are cell organelles found both in plant and animal cells as well as in protozoa but they are absent in bacteria (which have periplasmatic space instead of lysosomes , located between the plasma membrane and the cell wall which plays a role similar to lysosomes .
- In 1949 , De Duve using cell fractionation technique , isolated a class of particles which were found to have a high content of ACID PHOSPHATASE and other HYDROLYTIC ENZYMES . Because of these hydrolytic properties these particles were called LYSOSOMES (Gr lysis = dissolution ; soma = body)

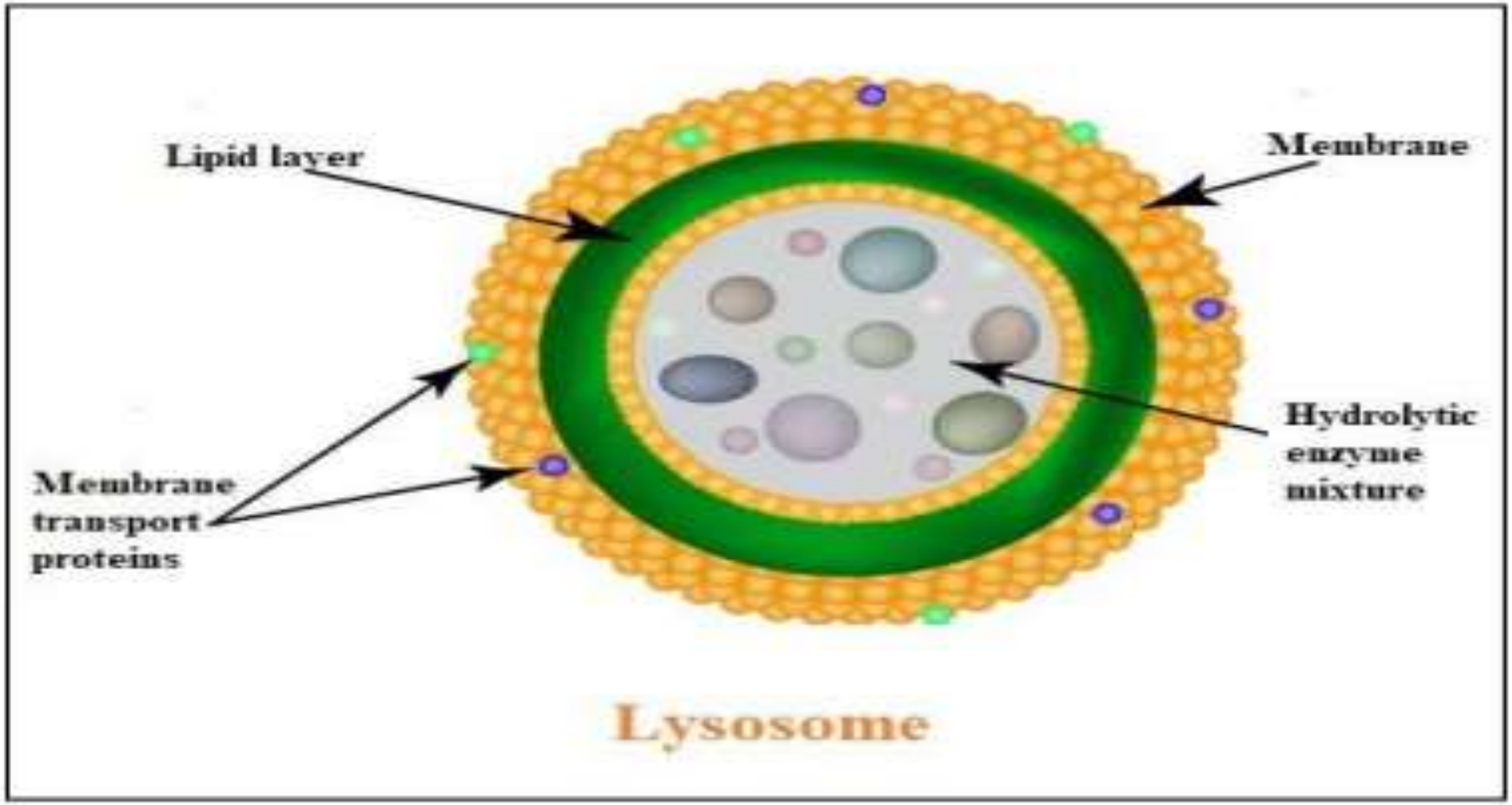


Lysosomes were discovered by the Belgian cytologist **Christian René de Duve** in the 1950s. (De Duve was awarded a share of the 1974 Nobel Prize for Physiology or Medicine for his discovery of lysosomes and other organelles known as peroxisomes). He also coined the term, lysosomes. Lysosomes (Gk. lysis- digestive or loose, soma- body) are small vesicles which are bounded by a single membrane and contain hydrolytic enzymes in the form of minute crystalline or semi crystalline granules of 5-8 nm.

Lysosomes: a sub cellular organelle that is found in nearly all types of eukaryotic cells (cells with a clearly defined nucleus) and is responsible for the digestion of macromolecules, old cell parts, and microorganisms. Each lysosome is surrounded by a membrane that maintains an acidic environment within the interior via a proton pump. It contains a wide variety of hydrolytic enzymes (acid hydrolases) that break down all types of biological polymers—proteins, nucleic acids, carbohydrates, and lipids.

Shape and Size of lysosome

The shape and size of lysosomes is variable. Morphologically they can be compared with Amoeba and white blood cells (W.B.C.). Due to their changing habit they cannot be accurately identified as the basis of the shape. Normally lysosomes vary in size from 0.4 to 0.8цm, but they may be as large as 5цт in mammalian kidney cells and are exceedingly large in phagocytes.


Lipid layer
Membrane
Hydrolytic enzyme mixture
Membrane transport proteins
Lysosome

- Lysosomes are an animal cell's digestive organelles and its main function is INTRACELLULAR and EXTRACELLULAR DIGESTION. These organelles function in one of the following ways:
- Digestion of food or various materials taken by phagocytosis or pinocytosis .
- Digestion of parts of the cell by Autophagy

(Auto= self ; Phagy =eating)

- Breakdown of extracellular material by the release of enzymes into the surrounding medium.

Properties of lysosomes

- A typical lysosome contains atleast 50 different hydrolytic enzymes (produced in the RER and targeted to this organelle) .Taken together lysosomes can hydrolyze virtually every type of biological macromolecule.
- All these enzymes share an important property i.e; all of them have their optimal activity at an acidic pH and therefore are ACID HYDROLASES. This pH optima of the enzymes is suited to the low pH of the lysosomal compartment which is app 4.6.

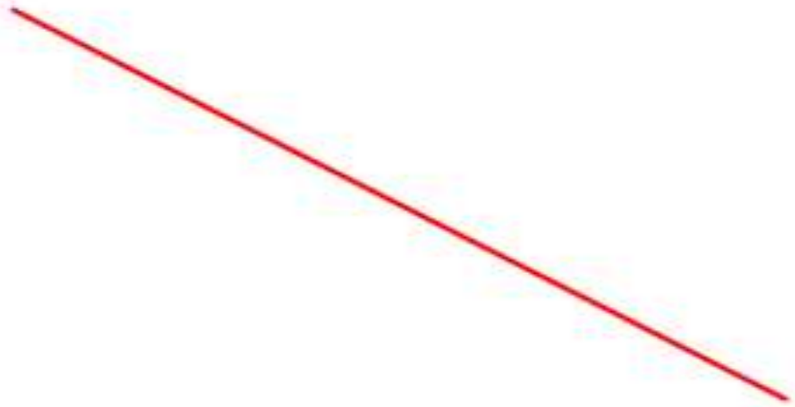
Lysosomal enzymes:

1. HYDROLASES ACTING ON ESTER BONDS:

I. Arylestrase
II. Acid phosphatase
III. Phosphodiesterase I
IV. Triglycerol lipase
V. Phospholipase A_1
VI. Phospholipase A_2
VII. Cholestrol esterase
VIII. Deoxyribonuclease II
IX. Ribonuclease II
X. Sphingomyelin phosphodiesterase
XI. Arylsulphatase A
XII. Arylsulphatase B
XIII. Chondroitin sulphatase

2. HYDROLASES ACTING ON GLYCOSYL COMPOUNDS:

I. Lysozyme
II. Neuroaminidase
III. Alpha glucosidase
IV. Beta glucosidase
V. Alpha galactosidase
VI. Beta galactosidase
VII. Alpha mannosidase
VIII Beta mannosidase
IX. Alpha-N-acetylglucosaminidase
X. Beta-N—acetylglucosaminidase
XI. Alpha-N-acetyl galactosaminidase
XII. Beta-N-acetyl galactosaminidase
XIII. Alpha-L-fucosidase
XIV. L-iduronidase



3. HYDROLASES ACTING ON ESTER PEPTIDE BONDS:

I. Carboxypeptidase A
II. Carboxypeptidase B
III. Carboxypeptidase C
IV Dipeptidase
V. Dipeptidyl peptidase
VI. Kininogen
VII. Elastase
VIII. Neutral Proteinase
IX Plasminogen activator
X. Cathepsin B
XI. . Cathepsin D
XII Cathepsin E
XIII CathepsinG
XIV. Renin
xv. Collagenase

4. HYDROLASES ACTING ON OTHER CARBON NITROGEN BONDS:

I. Aspartylglucosaminidase
II. Aminoacid naphthylamidase
III. Benzoyl arginine naphthylamidase

5. HYDROLASES ACTING ON ACID ANHYDRIDE:

I. Inorganic pyrophosphatase

6. HYDROLASES ACTING ON P-N BONDS:

I. Phosphoaminidase

7. HYDROLASES ACTING ON S-N BONDS:

I. Heparin sulfamidase

POLYMORPHISM

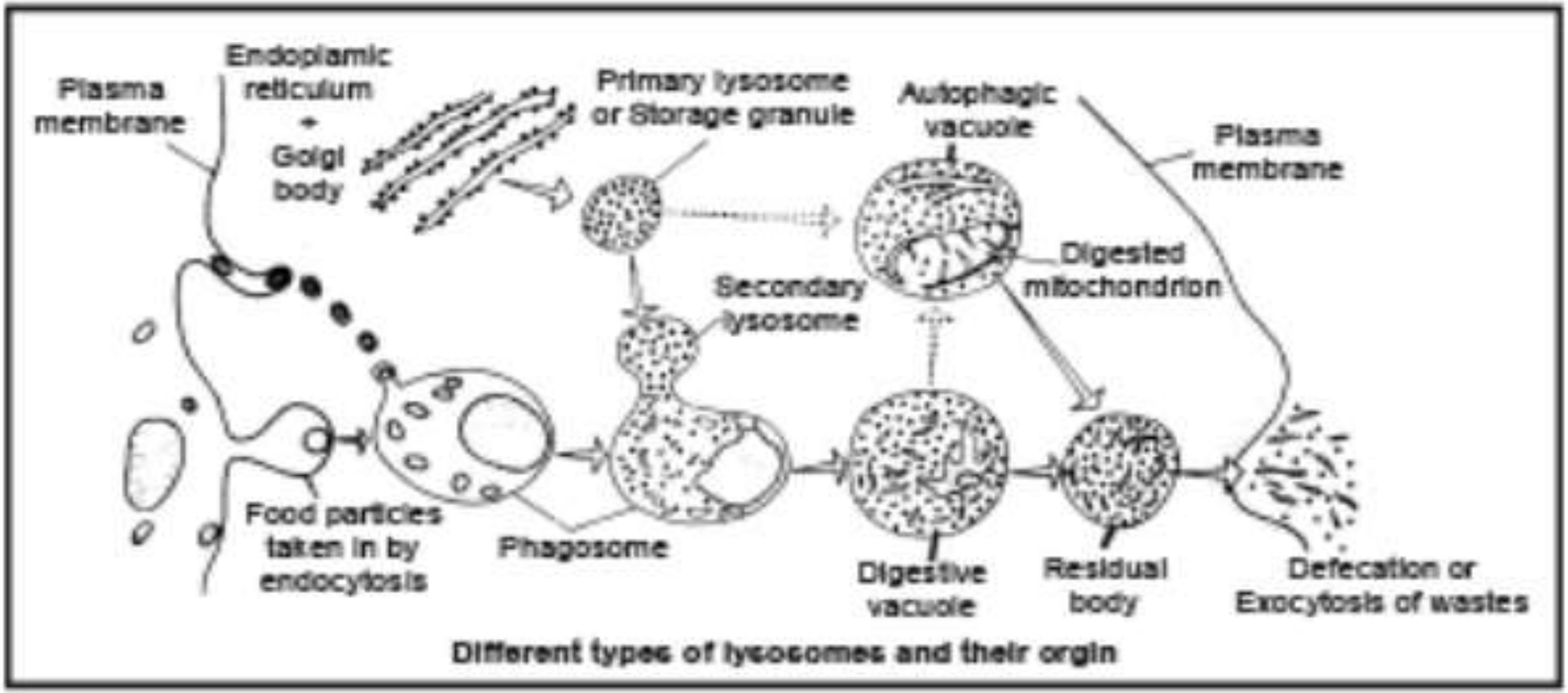
- The most remarkable morphological characteristic of lysosome is its polymorphism regarding its size and its internal structure
- According to the current interpretation , polymorphism is the result of primary lysosome with the different materials which are phagocytized by the cell.
- At present , four types of lysosomes are recognized of which only the first one is PRIMARY LYSOSOME and the other three may be grouped as SECONDARY LYSOSOMES.

1)Primary lysosomes :

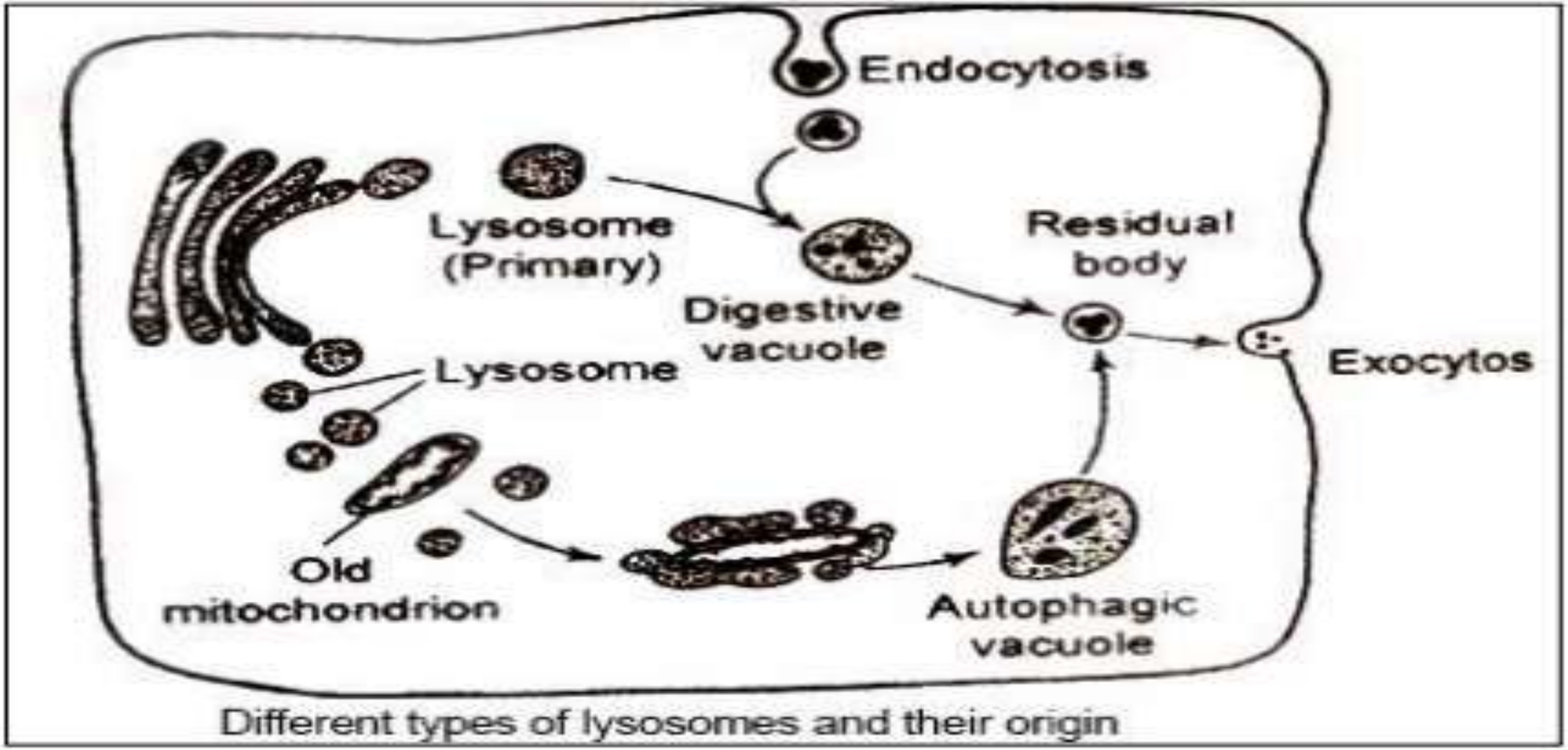
- This is a small body whose enzymatic content is synthesized by the ribosome . From there the enzymes penetrate via the E.R to the Golgi complex, in which the first acid phosphatase reaction takes place .The primary lysosome may be charged preferentially with one type of enzyme.

2)Secondary lysosome :

- Full complement of acid hydrolases is present in them. The secondary lysosomes are the following types:



Different types of lysosomes and their orgin



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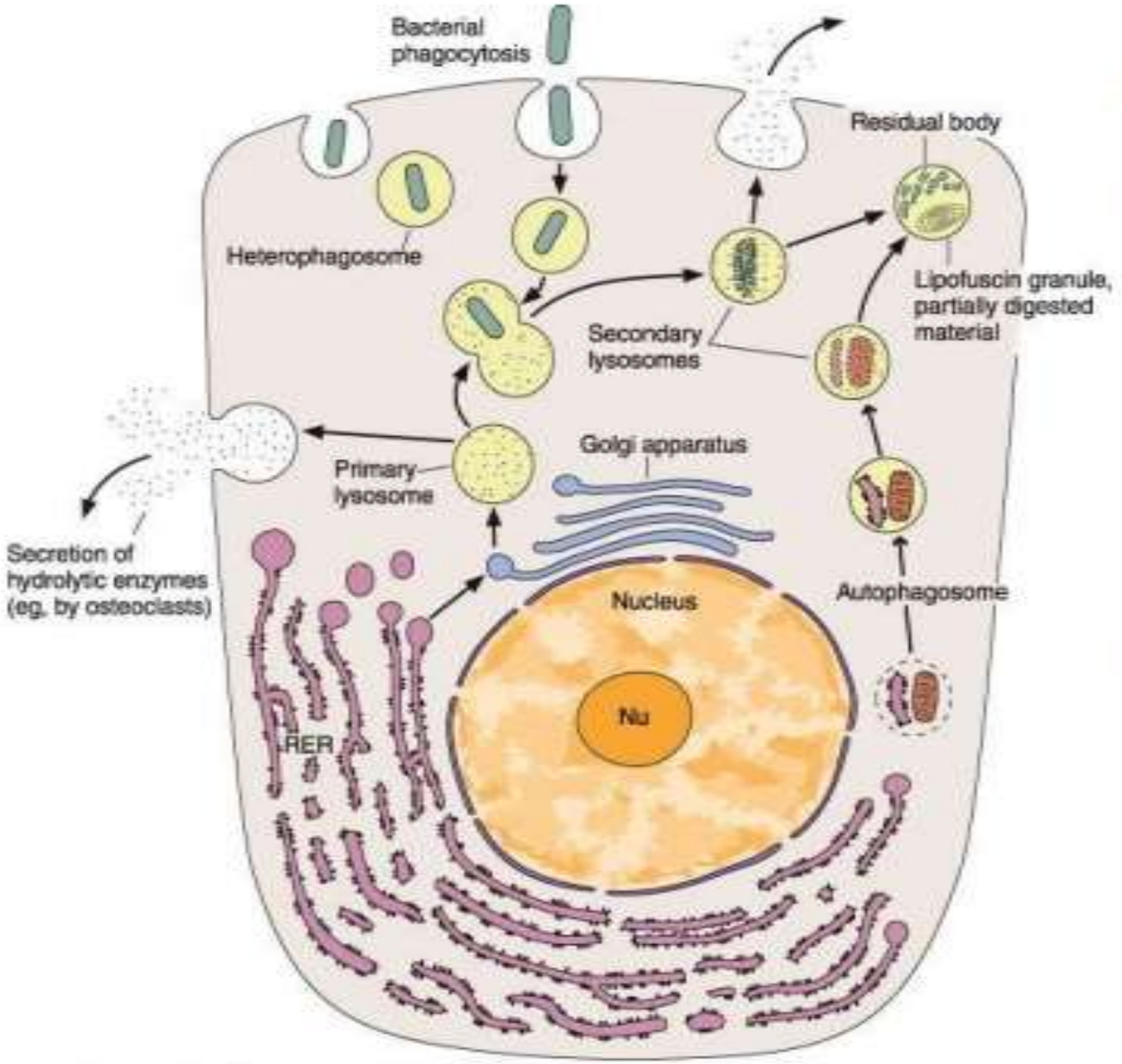


a) Heterophagosome /Digestive vacuole :

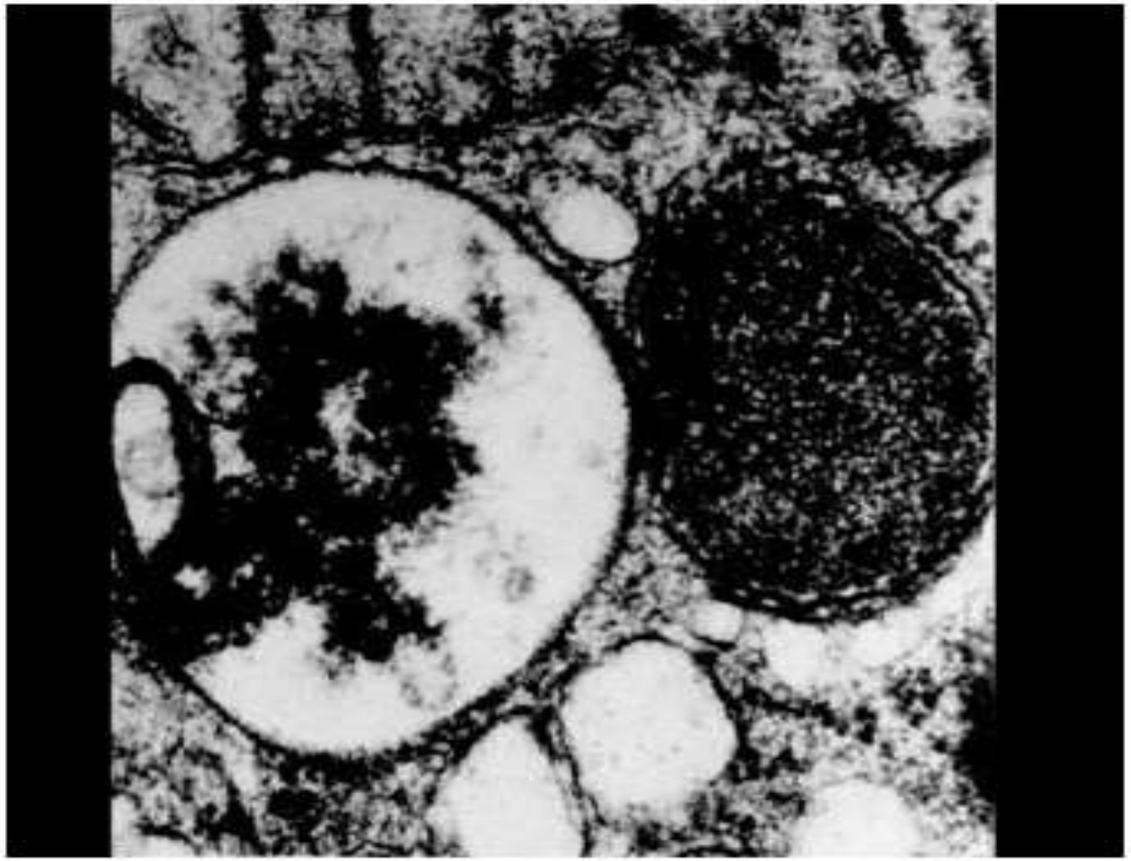
- This results from the phagocytosis or pinocytosis of foreign material by the cell. The digetsive vacuole contains positive phosphotase reaction. The negulfed material is progressively digetsed by the hydrolyric enzymes which have been incorporated into the lysosome.
- Under ideal conditions, digetsion leads to products of low molecular weight, which pass through the lysosomal membrane and are incorporated into the cell to be used again in many metabolic pathway.

b) Residual Body

- This is formed if the digestion is incomplete. In amoeba and other protozoans, the residual body is eliminated by defecation. In other cells, they may remain for a long time within the cytoplasm as a lypofuscin granule.

c) Autophagic vacuole/ cytolysosome/ autophagosome

- Lysosomes regularly engulf bits of cytosol which is degraded by a mechanism called Microautophagy
- During starvation the liver cells show numerous autophagic vacuole. This is a mechnaism by which cell degrades its own constituents such as mitochondria and ER



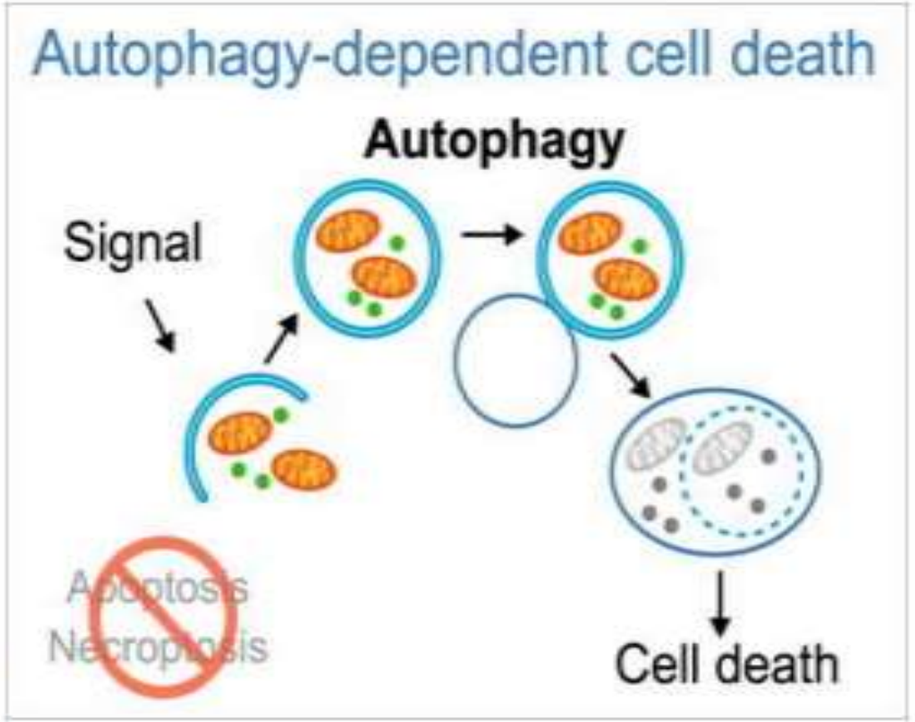
Functions of lysosomes

1. **Intracellular Digetsion**

- Within the secondary lysosomes, the ingested material or those resulting from autophagy are subjected to reaction of many hydrolases. Carbohydrates are hydrolysed to monosaccharides, proteins into dipeptides

2. **Autophagy**

- lysosomes bring about the renovation and turn over of cell components. Cytoplasmic organelles become surrounded by membranes of SER and lysosomal enzymes are discharged into the autophagal vacuoles and the organelles are digested. Autophagy is a mechnaism by which less important cell components are broken down to facilitate survival



3. Removal of cell and extra cellular material during developmental process

- Lysosomal bring about shedding or remodeling of tissues with the removal of whole cells and extra cellular material during developmental process

4. Release of lysosomal enzymes into the extra cellular medium

- The contents of the primary lysosomes may be released into the extra cellular medium by the process of exocytosis. This process is activated by parathyroid hormone and inhibited by calcitonin

5. Release of thyroid hormone

- Thyroid hormones (T3 &T4) are released from large protein molecule called thyroglubilin stored within the thyroid follicles

6. Leucocyte granules are of lysosomal nature

- All leucocytes of vertebrates contain granules which have many of the lysosomal enzymes. Monocytes have few lysosomes but when they enter the tissue and are transformed into macrophages they gain lysosomes.

Activated macrophage

7. Lysosomes imporatnt in germ cells and fertilization

- The acrosome of spermatozoan can be considered as the specialized lysosome which contains PROTEASE and HYALURONIDASE and abundant ACID PHOSPHATE. During fertilization, hyaluronidase disperses the cells of cumulus orphorus and protease digests zone pellucide making a channel through which the sperm nucleus penetrates the egg.
- In eggs lysosomes play a role in digetsion of stored reserves