Lysosomes

Lysosomes were discovered by the Belgian cytologist **Christian René de Duve i**n 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.

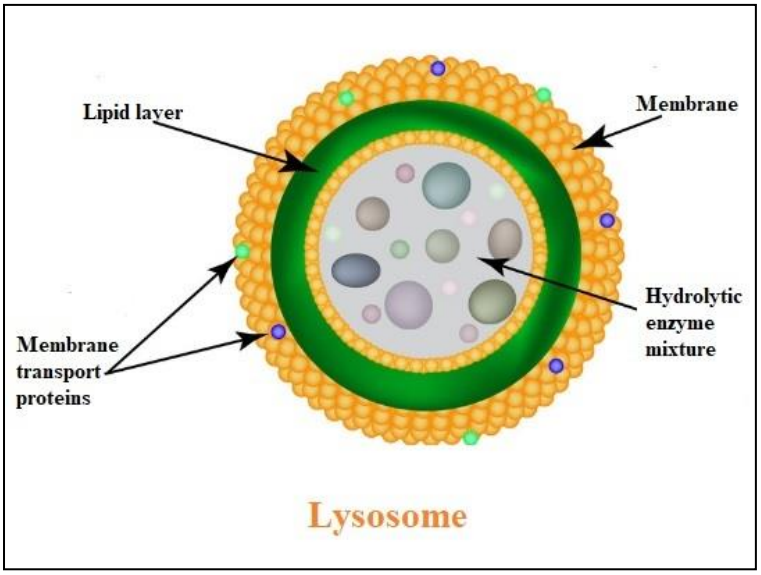
Lysosomes: a sub cellular organelle that is found in nearly all types of eukaryotic cells (cells with a clearly defined nucleus) and is responsible for the digestion of macromolecules, old cell parts, and microorganisms. Each lysosome is surrounded by a membrane that maintains an acidic environment within 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.

Structure of Lysosomes:

Like other cytoplasmic complexes, lysosomes are like round tiny bags filled with dense material and digestive enzymes.



A lysosome is basically a specialized **vesicle** that holds a variety of enzymes. The enzyme proteins are first created in the rough endoplasmic reticulum. Those proteins are packaged in a vesicle and sent to the Golgi apparatus. The Golgi then does its final work to create the digestive enzymes and pinches off a small, very specific vesicle. That vesicle is a lysosome. From there the lysosomes float in the cytoplasm until they are needed. Lysosomes are single-membrane organelles.
The enzymes of lysosomes are categorized in 6 groups: These are…

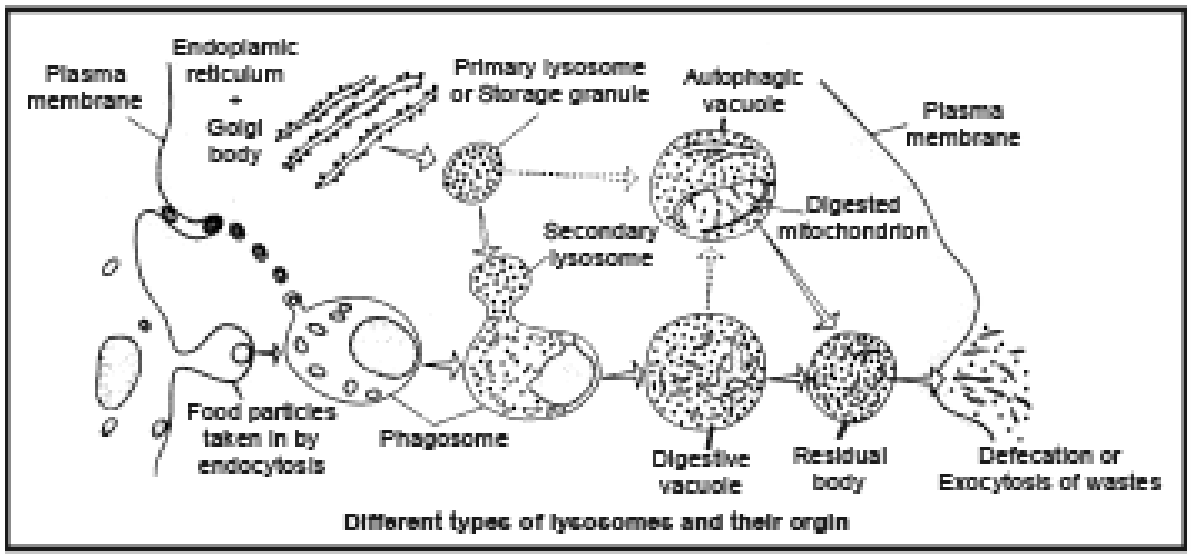
- **Nucleases** - Nucleases are important enzymes that hydrolyze nucleic acids. Nucleases are divided in to deoxyribonuclease (acts on DNA) and ribonuclease which hydrolyses RNA. Hydrolysis action on nucleic acids results in the production of sugars, nitrogen bases as well as phosphates.
- **Proteases** - 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 monosaccharide. 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 releasing phosphate in the process. However, the compound has to have a phosphate group.
- **Lipases** - Lipases include esterases and phospholipidases 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.

Function: Lysosomes contain about 45- 50 different degradative enzymes that can hydrolyze proteins, DNA, RNA, polysaccharides, and lipids. All of the lysosomal enzymes are acid hydrolases, which are active at the acidic pH (about 5) that is maintained within lysosomes but not at the neutral pH (about 7.2) characteristic of the rest of the cytoplasm. The requirement of these lysosomal hydrolases for acidic pH provides double protection against uncontrolled digestion of the contents of the cytosol; even if the lysosomal membrane were to break down, the released acid hydrolases would be inactive at the neutral pH of the cytosol. To maintain their acidic internal pH, lysosomes must actively concentrate H^+ ions (protons). This is accomplished by a proton pump in the lysosomal membrane, which actively transports protons into the lysosome from the cytosol. This pumping requires expenditure of energy in the form of ATP hydrolysis, since it maintains approximately a hundredfold higher H^+ concentration inside the lysosome. Acid hydrolases are targeted to lysosomes by mannose-6-phosphate residues, which are recognized by mannose-6-phosphate

receptors in the *trans* Golgi network and packaged into clathrin-coated vesicles. Following removal of the clathrin coat, these transport vesicles fuse with late endosomes, and the acidic internal pH causes the hydrolases to dissociate from the mannose-6-phosphate receptor. The hydrolases are thus released into the lumen of the endosome, while the receptors remain in the membrane and are eventually recycled to the Golgi. Late endosomes then mature into lysosomes as they acquire a full complement of acid hydrolases, which digest the molecules originally taken up by **endocytosis.**

In addition to degrading molecules taken up by endocytosis, lysosomes digest material derived from two other routes: **phagocytosis** and **autophagy**. In phagocytosis, specialized cells, such as macrophages, take up and degrade large particles, including bacteria, cell debris, and aged cells that need to be eliminated from the body. Such large particles are taken up in phagocytic vacuoles (phagosomes), which then fuse with lysosomes, resulting in digestion of their contents. The lysosomes formed in this way (phagolysosomes) can be quite large and heterogeneous, since their size and shape is determined by the content of material that is being digested.



Different types of lysosomes and their origin

Polymorphism of Lysosomes

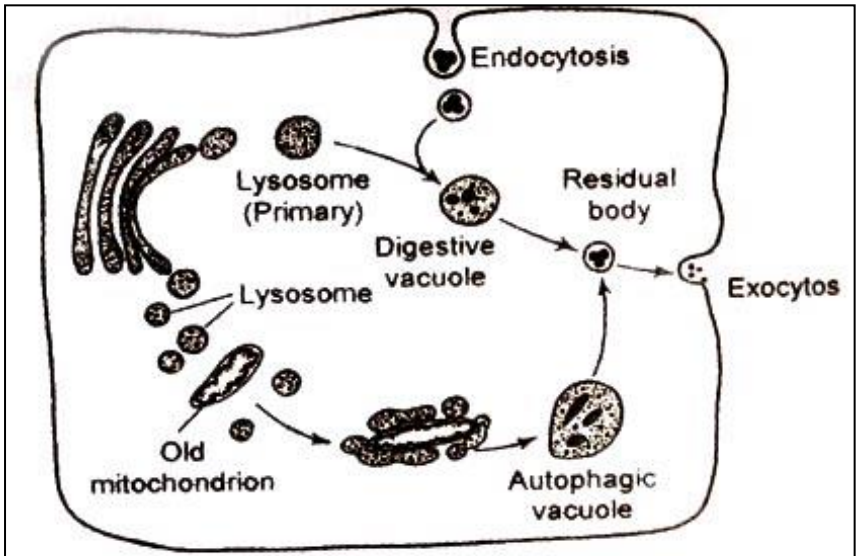
Lysosomes pass through various stages in the same cell. The phenomenon is called polymorphism or existence of more than one morphological form according to present concept as described by De Robertis et al., (1971); this polymorphism is the result of the association of primary lysosomes with the different materials that are phagocytized (literally 'eaten') by the cell.

Depending upon their morphology and function, there are four types of lysosomes— primary, secondary, residual bodies and auto-phagic vacuoles

1. Primary lysosome (storage granules):
It is a small sac-like body whose enzymatic contents are synthesized by ribosomes and accumulated in endoplasmic reticulum. From there, they enter the Golgi region, where acid phosphatase reaction takes place. The GERL region (The GERL is comprised of (1) Golgi apparatus, (2) endoplasmic reticulum, and (3) lysosome) i.e., acid phosphatase rich region of Golgi maturing face is thought to be involved in the production of lysosomes. The primary lysosome comprises only one type of enzyme or another.

2. Secondary lysosomes (digestive vacuole or heterophagosome):
These are produced either from phagocytosis or pinocytosis of foreign material by the cell. Actually within the cell the foreign bodies or extra-cellular substances are enclosed within the membrane after phagocytosis or pinocytosis and these membranes bound structures are known as phagosomes or pinosomes.

These ultimately fuse with primary lysosomes, thus forming secondary lysosomes. This body having engulfed material within membrane has also full complements of acid hydrolases (hydrolytic enzymes). The digested materials of these lysosomes pass through the lysosomal membrane and are incorporated into the cell so that they may be reused in metabolic pathways.



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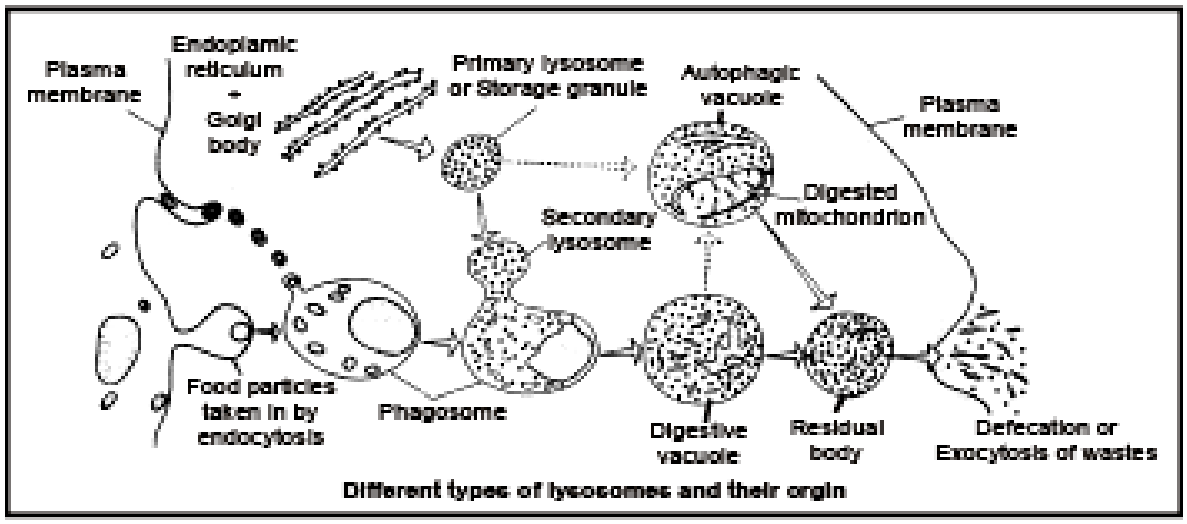
3. Residual bodies:
These are formed if the digestion is incomplete. In some cells, such as the Amoeba and other protozoa, these residual bodies are eliminated by defecation. Hence lysosomes

having undigested material or debris are called residual bodies. These bodies are formed due to lack of certain enzymes in lysosomes.

These are rejected from the cell by exocytosis and some time in certain cells these bodies remain in cells for long time causing ageing. These residual bodies also cause diseases in man such as fever, hepatitis, polynephritis, hypertension, congested heart failure, etc. If the debris, mostly lipid in nature, may accumulate and condense into concentric lamellae, it forms myelin figures.

4. Autophagic vacuole (cytolysosome or autophagosome):
It is a special case in which lysosome digests a part of cell (e.g., mitochondria or portions of ER) by the process of autophagy. For example, liver cell shows numerous autophagosomes during starvation among which remnants of mitochondria occur. This is a mechanism by which the cell can achieve degradation of its own constituents without irreparable damage.



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