LYSOSOME

✓ **Historical aspect** : In 1955 de Duve termed these organelles as lysosomes, because they contain digestive enzymes capable of lysis or digestion.

✓ **Origin** : Lysosomes may originate directly from the endoplasmic reticulum, or from the Golgi mem. & then associate with the vesicles which have arisen by pinocytosis or phagocytosis.

✓ **Occurence** : Prokaryotes do not have a well defined membrane system. However, prokaryotes are known to secrete extracellular enzymes. Some hydrolases have been located outside the cell membrane. So, it is suggested that such prokaryotic cells are surrounded by an extracytoplasmic lysosome.

E.M. & cytochemical studies have revealed the presence of membrane bound structures containing acid phosphatase in the protozoa. These are thought to represent the primary & secondary lysosomes. Lysosomes have been reported in several groups of vertebrates & invertebrates. Almost every animal tissue investigated has yielded evidence of the presence of lysosomes.

✓ **Structure** :

① Generally they are globular & range in diameter from 0.2 to 0.8 microns. Under the EM lysosomes appear dense & finely granular.

② Lysosomes are bounded by a single lipoprotein membrane. The membrane is impermeable to substrates of the enzymes contained in the lysosome.

Certain substances, called labilizers, cause instability of the lysosomal membrane, leading to release of enzymes from the lysosome. Other substances, called stabilizers

Stabilizers - Substances that help to stabilise the membrane of lysosomes so that they do not release their contained enzymes.

✓ Labilizers — Vit A, D, K, E, Progesterone, testosterone, etc.

✓ Stabilizers — Cholesterol, Cortisol, Vit E (low conc.), Heparin etc.

The limited permeability of lysosomal membranes explains why lysosomal hydrolases do not have a direct access to cellular components. This prevents uncontrolled digestion of the cell contents by the lysosomal enzymes.

(3) An H+ pump in the lysosomal membrane uses the energy of ATP hydrolysis to pump H+ into the lysosome, thereby maintaining the lumen at its acidic pH. The acid hydrolases are hydrolytic enzymes that are active under acidic conditions.

(4) Lysosomal enzymes —

	Enzyme	Substrate	Products
①	Nucleases	Polynucleotides	Base + Phosphate + pentose
	Acid ribonuclease	RNA	
	Acid deoxy "	DNA	
②	Acid phosphatase	Most phospho-monoesters	Monophosphates
③	Lipase	Lipid	Fragments of lipid.
	Esterase	Fatty acid esters.	
	Phospholipase	Phospholipids	
④	Protease	Proteins	Amino acids.
	Collagenase	Collagen	
	Peptidase	Peptide	
⑤	Sulfatase	Sulphate ester	Fragments.
	Etc.		

Occurrence:

With the exception of mammalian R.B.C., the lysosomes have been reported practically from all the animal cells. The presence of lysosomal particles have also been suspected (and in some cases established) in protista (protozoan, slime-moulds, fungi, algae and prokaryotic protista). In plant cells, considering the evidences as a whole, there now seems little doubt about their presence.

Further, they have strong affinities with the lysosomes of animals and protista (Pitt and Galpin 1973). In plants, further they should not be confused with spherosomes in function. According to Pitt lysosomes and spherosomes are two different organelles and the latter are comparable to lipid droplets of animal. Yatsu and Jack (1972) have clearly shown that spherosomes are morphologically distinct organelles. Gahm (1973) reviewed the occurrence and histochemistry of plant lysosomes.

Polymorphism:

Lysosomes are polymorphic in nature. The polymorphic nature is due to variation in contents of lysosomes with different stages of digestion.

Generally lysosomes can be traced in four forms given below:

1. Primary lysosomes:

These are also called the true, pure or original lysosomes, having a single unit membrane containing enzymes in the inactive forms.

2. Secondary lysosomes:

These are also called the phagosomes as they contain the engulfed material and enzymes. The fused mass is called the secondary lysosome. The enzymes present in such lysosome gradually digest the engulfed material.

3. Residual or Lysosomes:

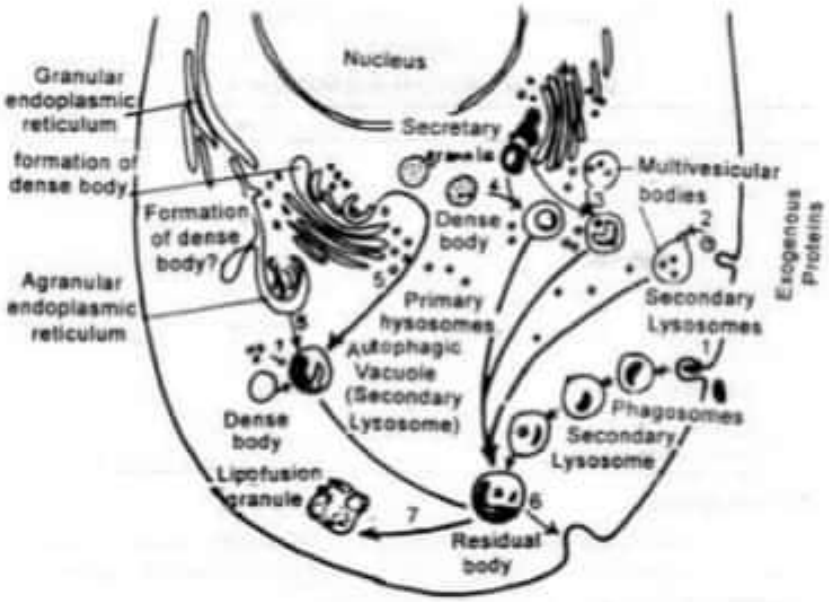
Lysosomal membrane characterized by the presence of undigested materials like myelin figure is called residual body.

4. Autophagic Vacuoles:

The autophagic vacuoles are also known as autophogosomes or cytolysosoms. The autophagic vacuoles are formed when the cell feeds on its intracellular organelles such as the mitochondria and endoplasmic reticulum by the process of autophagy. In such cases, the primary lysosomes are concentrated around the intracellular organelles and digest them ultimately.

The autophagic vacuoles are formed in special pathological and physiological conditions. C. de Duve (1967) and Allison (1967) have observed that during starvation

on the organisms many autophagic vacuoles developed in the liver cells which feed on the cellular components.



Polymorphism of Lysosomes

Functions of Lysosome

1. Extracellular digestion - Lysosomal enzymes maybe released outside the cell where they take part in the hydrolysis of extracellular material as for eg. bone consists of a matrix of collagen fibres & minerals in which osteoblasts, osteoplasts & osteocytes are embeeded. The multinucleate osteoplasts release lysosomal enzyme & degrade the organic matrix. Again ~~&~~ saprophytic fungi utilise extracellular digestion for their nutrition.

2. Intracellular digestion - Majority of the hydrolases in the lysosome have acid - pH optima (pH = 4) & the intracellular digestion is of 2 types :-

   a. Autophagy - It is the intracellular digestion in which obsolete cytoplasmic materials including old mitochondria, parts of E.R & golgi, cytoplasm etc. are enclosed by the membrane derived from E.R in the cell & these are broken down into simpler organic micromolecules that recycled for the synthesis of cellular components. This type of autophagy is very much ~~impot~~ important during physiological remodelling during embryonic stage & metamorphosis of larval stage.

   b. Heterophagy - It means the uptake of foreign substance by the process of phagocytosis & pinocytosis. In macrophages killing of germs are done by this process.

3. Harmone secretion - The follicles of the thyroid gland contain thyroglobulin which is stored as colloide in the lumen. The colloids containing ~~by~~ thyroglobulin enter epithelial cell by pinocytosis. It fuses with the primary lysosome with the 2ndary lysosome. The thyroxine & triiodothyronine are released by the action of proteolytic enzymes of the lysosome & then into the bloodstream.

4. Fertilisation & developmental process - During fertilisation the sperm releases hydrolytic enzymes from the acrosomal vesicel.

Infact the acrosomal vesical has been looked upon as a giant lysosome.

A large amt of larval tissue are destroyed during metaphorphosis of insects & amphibian. It takes place in an organised & sequential manner. The products of tissue digestion are ~~not~~ utilised in the synthesis of tissues of the adult form. eg: the limb buds in amphibia & wing buds in insects.

Again if the egg is not fertilised the endometrium breaks down & is released in menstruation. Phagocytes become active & are rich in lysosome during endometrial breakdown.

3. Skin pigmentation - Melanocytes in the skin produce & store pigments in their lysosome. These pigment containing melanosome release their pigment into the extracellular space by exocytosis. The pigment is then taken up by keratinocytes, leading to normal skin pigmentation. In some genetic disorder this transfer process is stopped owing to defects in melanosome exocytosis leading to form of hypopigmentation (albinism).

Lysosome & diseases

~~Accm~~

1. Increase in Autophagy - There maybe increased & uncontrolled autophagy resulting in excessive lysis activity.

2. Carcinogenesis - Chromosome abnormality has been implicated in carcinogenesis. It has been suggested that abnormal release of lysomal enzymes might be a cause of chromosome breakage.

3. Storage disease - There maybe ingestion of foreign material by heterophagy producing conditions like silicosis & asbestosis. Inhalation in silica causes severe lung reac.^{n}, the reaction is called silicosis. Silica is ingested by cells of lungs by phagocytosis. Even the released silica particles are taken up by other lysosome where the process is repeated.

Disease	*Enzyme deficiency*	*Material (substrate) accumulated*
Gaucher's disease	β-glucocerebrosidase	Glucosylceramide
Inclusion cell disease (I-cell disease or mucolipidosis II)	Numerous lysosomal enzymes absent	Glycolipids, glycoproteins, sialyloligosaccharides
Metachromatic leucodystrophy	Arylsulphatase A	Sulphatides
Niemann–Pick disease	Sphingomyelinase	Sphingomyelin
Sphingolipidosis GM_1 gangliosidosis	β-galactosidase	GM_1 gangliosides
Tay–Sachs disease	Hexaminidase A	GM_2 gangliosides

Table 9.1 Examples of lysosomal storage diseases