PEROXISOMES

MBOTCC-10
Unit-I

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Introduction: General Features

Peroxisomes are ovoid granular micro-bodies limited by a single membrane and reportedly occurring in both plant and animal cells. Peroxisomes were first described by a Swedish doctoral student Rhodin (1954). They were first isolated by the Belgian cytologist C. de Duve (1965) from the liver cells by using cell fractionation techniques.

They are rich in some oxidative enzymes such as peroxidase, catalase, D-amino oxidase, and urate oxidase.

The name peroxisome was used because these organelles were found specifically involved in the formation and decomposition of hydrogen peroxide (H_2O_2) by their catalase enzyme.

Peroxisomes are also known to carry out β-oxidation of fatty acids.

In the cells of endosperm or cotyledons of fat-storing seeds some organelles morphologically similar to peroxisomes are found with their enzymatic make up of the glyoxylate cycle. They are called glyoxysomes.

Peroxisomes are present in the photosynthetic cells of the leaves of higher plants. They are also found in the leaves of several CAM plants.

Morphology:

(i) Single membrane-bound ovoid granular structures.

(ii) They contain a fine granular matrix condensed at the centre, thus forming an opaque homogeneous core.

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(iii) Average diameter: 0·6 – 0·7 μm

(iv) Number of peroxisomes per cell varies between 70 and 100, depending on the cell type and environmental conditions.

– Compartmentalization creates an optimized environment to promote various metabolic reactions within peroxisomes.

(v) In many tissues, peroxisomes show a crystal-like body made of tubular subunits.

– Number of organelles having these bodies is sometimes correlated with the content of urate oxidase.

(vi) Smaller peroxisome-like bodies lacking an opaque core are found in many kinds of cells. They are called microperoxisomes.

Biogenesis of Peroxisomes:

(i) Mechanism of biogenesis of peroxisomes is complex and not completely known.

(ii) Peroxisomal membrane proteins are possibly synthesized in the ER, but both organelles have different protein composition.

(iii) Previously peroxisomes were considered to be formed as dilations or 'buddings' from the ER which became swollen and filled with electron dense material.

However, most peroxisomes exist without connections to the ER but with transient interconnections between themselves.

(iv) Peroxisomal and glyoxysomal enzymes are synthesized in the

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cytosol on free ribosomes, and are then incorporated, post-transcriptionally, into these organelles.

(v) The main peroxisomal enzyme catalase is made as a monomeric precursor (apoenzyme) which, after being in the cytosol with a half-life of 14 minutes, is translocated into the peroxisome.

— Inside the peroxisome, 'heme' is added and the final enzyme (holo-enzyme) becomes active, with a half-life of 36 hours.

(vi) It is assumed that the peroxisome as a whole grows slowly and is destroyed, probably by autophagy, with a half life of 5-6 days.

(vii) These studies have led to a mixed model of peroxisome biogenesis.

This model visualizes that:

— Membrane proteins are mainly synthesized on membrane-bound ribosomes, and

— Peroxisomal enzymes are produced in the cytosol on free ribosomes and are translocated into the organelle.

Peroxisomal Enzymes:

(i) Peroxisomes isolated from liver cells contain four enzymes related to the metabolism of H_2O_2.

— In fact, three of them — urate oxidase, D-amino oxidase, and α-hydroxylic acid oxidase produce H_2O_2, and catalase destroys it.

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(ii) Urate oxidase, and two other enzymes are related to the catabolism of purines in amphibian and avian peroxisomes.

(iii) Peroxisomal β-oxidation of fatty acids is carried out in mitochondria involving several enzymes like acyl-CoA oxidase, enoyl-CoA hydratase, 3-hydroxyacyl CoA and 3-ketoacyl-CoA thiolase.

- These enzymes serve to activate and oxidize fatty acids and to produce acetyl-CoA for anabolic reactions.

- Because of these functions peroxisomes play a role in thermogenesis in hibernating animals.

(iv) β-oxidation enzymes are synthesized on free ribosomes, and they are packaged into peroxisomes without a proteolytic processing.

(v) Other enzymes present in peroxisomes include glycolate oxidase, glutamate: glyoxylate aminotransferase, serine: glyoxylate aminotransferase, glutamate: oxaloacetate aminotransferase, hydroxy-pyruvate reductase, etc.

(vi) Enzymatic composition of peroxisomes varies according to the tissues.

Functions of Peroxisomes:

Peroxisomes play a significant role in the following major events of various living organisms:

1. Hydrogen Peroxide (H_2O_2) metabolism

Enzymes present in peroxisomes

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both lead to the production and elimination of H_2O_2 which is a reactive oxygen species.

2. Oxidation of Fatty Acids

Oxidation of fatty acids in animal cells occurs in both peroxisomes and mitochondria, but in yeasts and plants, it is only limited to peroxisomes.

Oxidation is accompanied by the production of H_2O_2 which is decomposed by catalase enzyme. This provides a major source of metabolic energy.

3. Lipid biosynthesis

Synthesis of cholesterol and dolichol occurs in both ER and peroxisomes. Bile acid synthesis takes place from cholesterol in the liver.

Peroxisomes contain enzymes to synthesize plamalogens, a family of phospholipids, which are important membrane components of the tissues of the heart and brain.

4. Germination of seeds

Peroxisomes in the seeds are responsible for the conversion of stored fatty acids to carbohydrates, critical to provide energy and raw materials for the growth of germinating seedlings.

5. Photorespiration

Peroxisomes in the leaves of green plants carry out photorespiration process along with chloroplasts.

6. Degradation of Purines

Peroxisomes carry out the catabolism of purines, polyamines and amino acids especially by uric acid oxidase.

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7. Bioluminescence

Luciferase enzyme found in the peroxisomes of fireflies helps in bioluminescence and this aid the flies in finding a mate or the food.

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