Peroxisome

Peroxisomes are membrane-bound organelles in most eukaryotic cells, primarily involved in lipid metabolism and conversion of hydrogen peroxide intowater and oxygen.

In 1954, electron microscope study of kidney tubule cells revealed a membrane-bound particle of approximately 0.5-1.0 µm diameter with a dense granular appearance. Since, nothing has been known of its function, it was simply termed a microbody which was found subsequently in many other eukaryotic cells. Later on they have been divided into two categories; viz. peroxisomes that are found in both animals and plants and glyoxysomes that are found only in plants. These were named peroxisomes because they are the site of formation of hydrogen peroxide, highly reactive and toxic oxidizing agent followed by its breakdown into oxygen and water. Peroxisomes shares two features with mitochondria: they engage in oxidative metabolism and import their proteins posttranslationally from cytosol.

Structure

Peroxisomes are organelles that can vary in shape, size and number depending on the energy requirement of the cell. In yeast cells, a carbohydrate-rich growth medium shrinks peroxisomes. On the other hand, the presence of toxins or a lipid-rich diet can increase their number and size.

Peroxisomes are simple, membrane-bounded vesicles that often contain a dense crystalline core. These are made of a phospholipid bilayer with many membrane-bound proteins – especially those that act as protein transporters.Enzymes involved in detoxification and lipid metabolism are synthesized on free ribosomes in the cytoplasm and selectively imported into peroxisomes.

Enzymes and proteins destined for the peroxisome usually contain one of two signal sequences. There are short stretches of few amino acids that determine subcellular location of the protein. The more common signal sequence is called Peroxisome Targeting Sequence 1 (PTS1), which consists of an amino acid trimer. Proteins containing PTS1 signal sequence have a serine residue followed by a lysine and then a leucine residue in their carboxy-terminal end. A large proportion of peroxisomal proteins have this signal sequence. For PTS1 to function optimally, amino acid sequences upstream of this trimer are also necessary. It is suggested that the C-terminal sequence should ideally be seen as a stretch of 20 amino acids that are necessary for recognition of protein by peroxisomal transporter and translocator molecules.

Alternatively, a peroxisomal protein could also have an N-terminal signal sequence consisting of 9 amino acids. This sequence is made of two dimers separated by a stretch of 5 amino acids. The first dimer is made of arginine and leucine, while second dimer is made of histidine and leucine. This signal sequence is represented using the single letter amino acid code as RLx5HL.

There is some evidence that there are other internal sequences that target proteins for import into peroxisome but that have not yet been characterized. Peroxisomes also contain some enzymes at very high concentrations, occasionally appearing to have a crystalloid core.

As a peroxisome grows in size due to the entry of proteins and lipids, it divides into 2 organelles.

Functions

1. Metabolism of hydrogen peroxide: Hydrogen peroxide (H_2O_2) is a highly reactive and toxic oxidizing agent. It is formed by a number of enzymes, viz. urate oxidase, glycolate oxidase and amino acid oxidases. They utilize molecular oxygen to oxidize their respective substrates. The generated in these reactions is rapidly broken down by the enzyme catalase to liberate water and oxygen. These enzymes are synthesized in cytosol and then transported into the peroxisomes.

2. Breakdown of fatty acid by β-oxidation: In animal, β-oxidation of fatty acids occurs in both mitochondria and peroxisomes while in plant, it occurs only in peroxisomes. One molecule of acetyl Co-A and carbon dioxide are liberated at each oxidation with the formation of fatty acid which is two C-atom shorter than the original one.

3. Synthesis of plasmalogen: Plasmalogens are an important class of phospholipids in brain tissue in which one of the fatty acids is linked to the glycerol by an ether linkage rather than an ester linkage.

4. Generation of light in fireflies: The enzyme luciferase which generates light in fireflies is a peroxisomal enzyme.

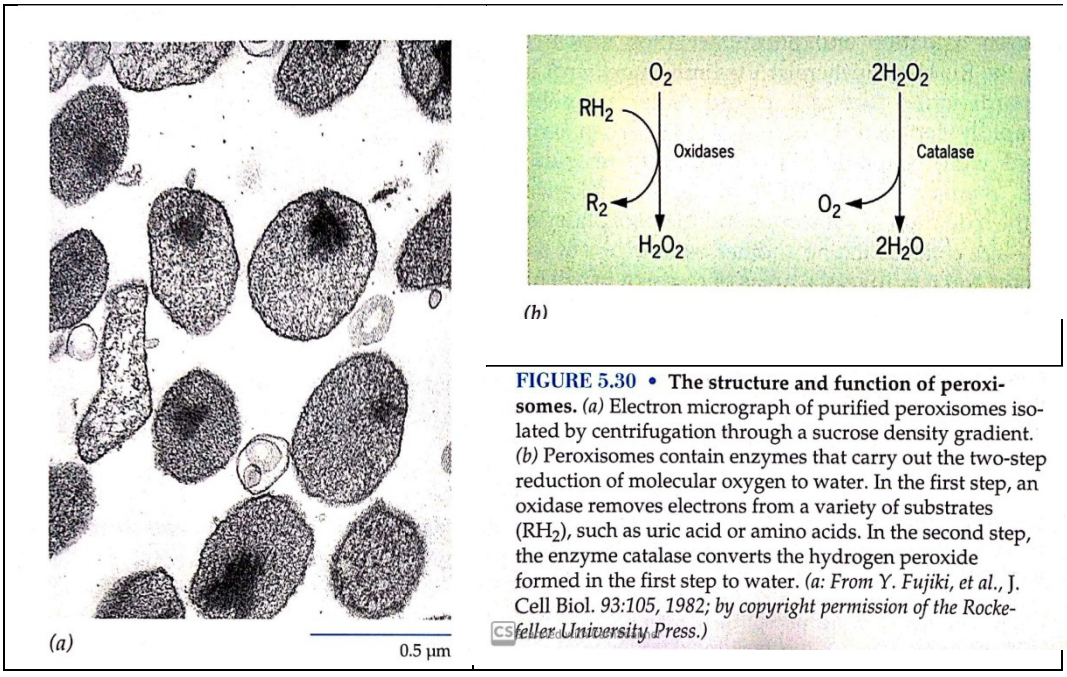

FIGURE 5.30 • The structure and function of peroxisomes. *(a)* Electron micrograph of purified peroxisomes isolated by centrifugation through a sucrose density gradient. *(b)* Peroxisomes contain enzymes that carry out the two-step reduction of molecular oxygen to water. In the first step, an oxidase removes electrons from a variety of substrates (RH_2), such as uric acid or amino acids. In the second step, the enzyme catalase converts the hydrogen peroxide formed in the first step to water. *(a: From Y. Fujiki, et al.,* J. Cell Biol. *93:105, 1982; by copyright permission of the Rockefeller University Press.)*

Source: Cell and Molecular Biology, Karp G (1996), 205-206.
Source: https://biologydictionary.net/peroxisome/

Further Readings:

Molecular Biology of the Cell, Alberts et al. (2002), https://www.ncbi.nlm.nih.gov/books/NBK26858/
The Cell: A Molecular Approach, Cooper G M (2000), https://www.ncbi.nlm.nih.gov/books/NBK9930/