The end product of β-oxidation of fatty acid is acetyl-CoA. Fatty acids having odd number of carbon atoms form acetyl-CoA and propionyl-CoA. The acetyl-CoA has been either oxidized for the production of ATP or converted into carbohydrates. The propionyl CoA gets converted to malonic semialdehyde in both plants and animals. Malonic semialdehyde could be converted to alanine by transamination with glutamic acid in animals. In plants, however, this compound gets oxidised to CO_2 and H_2O.

α-Oxidation of Fatty Acid's

The alpha oxidation of long chain fatty acids taxes place at the second or alpha position of the chain. The enzymes catalysing α-oxidation are located in the endoplasmic reticulum. It does not need CoA intermediates and does not produce high energy phosphates. There occurs direct hydroxylation of long chain fatty acid at the α-carbon to produce α-hydroxy fatty acid which gets oxidatively decarboxylated to eliminate one carbon atom from the carboxyl and of the molecule (Fig. 13.3)

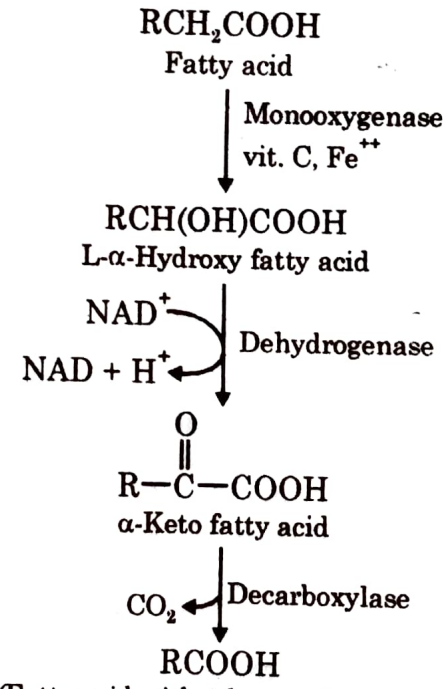


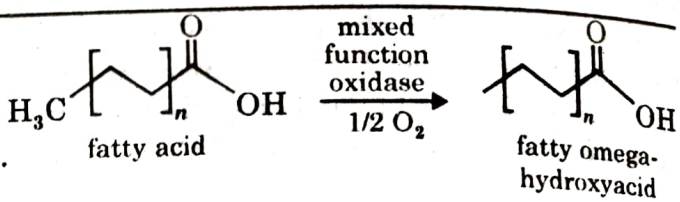
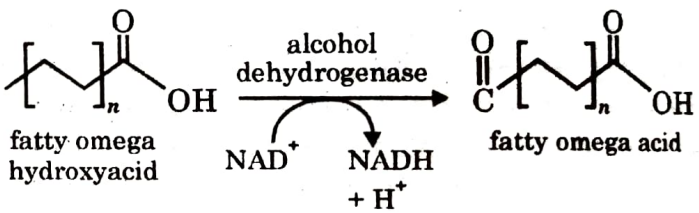
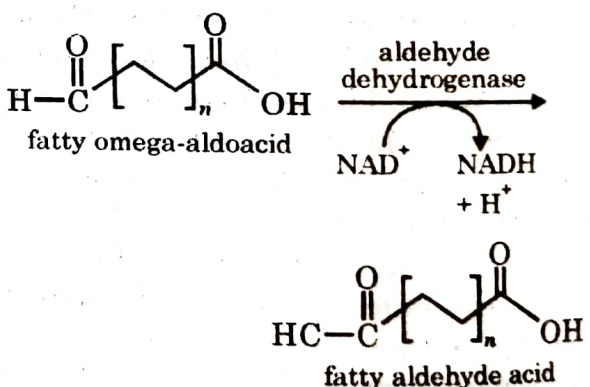
Fig. 13.3 : α-Oxidation of fatty acid.

Alpha oxidation is helpful in the oxidation of fatty acids that are having a methyl group on β-carbon which blocks β-oxidation. Phytanic acid, derived from phytols, is present in plant foods, is having a methyl group at β-carbon which blocks β-oxidation. Refsum's disease : It is a disorder because of genetic defect in the oxidation. The biochemical defect is the lack of α-hydroxylase (phytanic acid oxidase), consequently phytanic acid accumulates in the blood and tissues, giving rise to neurological and skeletal abnormalities.

Omega Oxidation of Fatty Acids

Omega Oxidation is a process of *fatty acid metabolism* in some species of animals, an alternative pathway of *beta oxidation,* of which involving the oxidation of the ω carbon, the carbon most distant from the *carboxyl group,* of a fatty acid. The process is normally a minor catabolic pathway for medium-chain fatty acid (10-12 carbon atoms), but becomes more important when β-oxidation is defective.

In vertebrates, the *enzymes* for ω oxidation are located in the *endophasmic reticulum* of *liver* and *kidney* instead of *mitochondria* for β oxidation. The steps of the process are as follows :

Reaction type	*Enzyme*	*Description*	*Reaction*
Hydroxy-lation	mixed func -tion oxidase	The first step introduces a *hydroxyl group* onto the ω-carbon. The oxygen for the group comes from molecular oxygen in a complex reaction that involves *cytochrome P450* and the electron donor	
Oxidation	alcohol dehydroge-nase	The next step is the *oxidation* of the hydroxyl group to an aldehyde by NAD.	
Oxidation	aldehyde dehydroge-nase	The third step is the *oxidation* of the aldehyde group to a *carboxylic* acid by NAD^+. The Product of this step is a fatty acid with a carboxyl group at each end.	

After the three steps, either end of fatty acid can be attached to ***coenzyme A.*** The molecule can enter the mitochondrion and undergo β-oxidation. The final products after successive oxidation include *succinic acid,* which can enter *citric acid cycle,* and *adipic acid.*

Conversion of Fats into Carbohydrates

There are some fat storing seeds, bacteria and fungi in which fats are converted readily into sucrose and other complex sugars. Some of the carbon atoms of the fats are also converted into amino acids. The process called *glyoxylate cycle* is carried out in special cell organelles called *glyoxysomes.* However, it is important to be emphasized that glyoxysomes are present only in those tissues which convert fat into carbohydrate. It was H.L. Kornberg of Oxford University who worked out on this cycle in the late 1950s.

In this cycle, first of all acetyl-CoA derived from the mitochondrial fatty acid oxidation gets diffused to the *glyoxysomes.* In these, acetyl CoA may condense, with

oxaloacetate to form citrate involving the enzyme *citrate synthetase*. Then citrate gets isomerised to isocitrate by the enzyme aconitase. Now isocitrate may get converted to malate through Kreb's cycle intermediate, thereby forming CO_2. However, in glyoxysomes, it gets cleaved primarily to succinate and glyoxylate by the enzyme called isocitrase. Out of these, succinate may be involved in the synthesis of sugars and amino acids by interacting with some of the Kreb's cycle intermediates and by the reversal of glycolytic pathway. On the other hand, the other product called glyoxylate may interact with another molecule of acetyl-CoA thereby forming malate, in the presence of enzyme, malate synthetase. At a later stage, malate dehydrogenate brings about oxidation of malate to oxalacetate, which may undergo another round of acylation to form citrate. The glyoxylate has been depicted in Fig. 13.4.

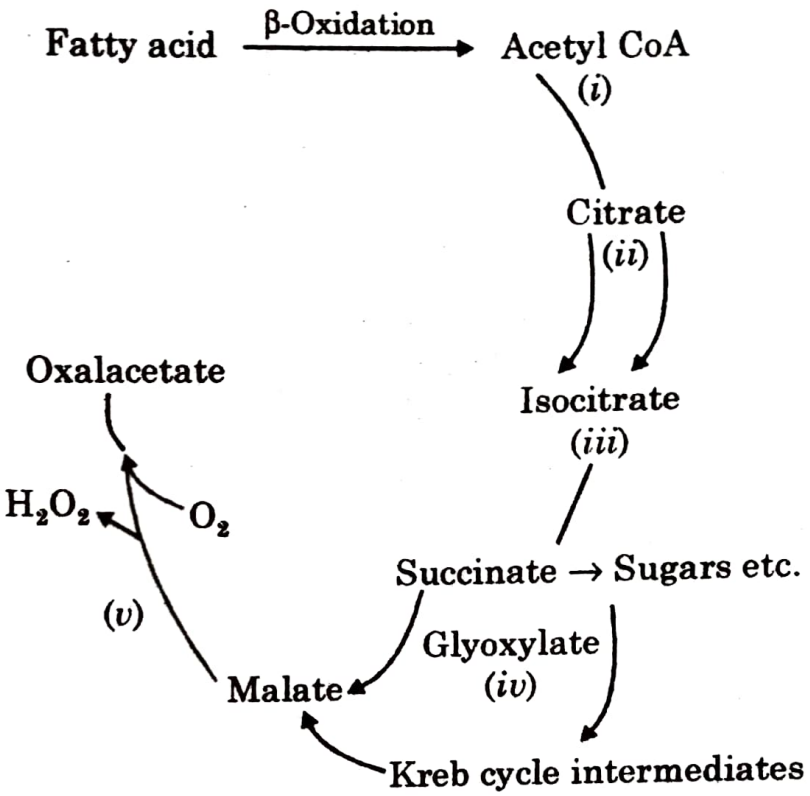


Fig. 13.4 : Glyoxylate cycle. Enzyme—(*i*) Citrate synthetase, (*ii*) Aconitase, (*iii*) Isocitratase, (*iv*) Malate synthetase, (*v*) Malate dehydrogenase

The overall result of glyoxylate cycle involves the conversion of 2 moles of the synthesis of proteins and sugars. Had no cycle been operated, isocitrate formed in the second step (Fig. 13.4) would have been converted into malate via succinate and fumarate during which carbons are lost as CO_2. In the glyoxylate cycle, these CO_2 yielding reactions are not taking place and the 2 carbons of acetyl—CoA remain conserved.

Biosynthesis of Fat

Fats are synthesised from fatty acids and glycerol by the reversal of hydrolytic process.

1. Biosynthesis of saturated fatty acids : It was believed for long that fatty biosynthesis was the reversal of the pathway of fatty acid degradation. However, several major points of difference between the degradation and biosynthesis of fatty acids are known. These are given as follows :

(*i*) CoA-derivatives do not act as the substrates of the enzymes in fatty acid synthesis but instead acyl moieties are connected to an *acyl carrier protein* (ACP). ACP has a molecular weight of 10,000. Its prosthetic group is 4′-phosphopantetheine and it thus resembles coenzyme A (Fig. 13.5).

(*ii*) In biosynthesis, the basic "adding unit" is malonyl-CoA but not acetyl-CoA.