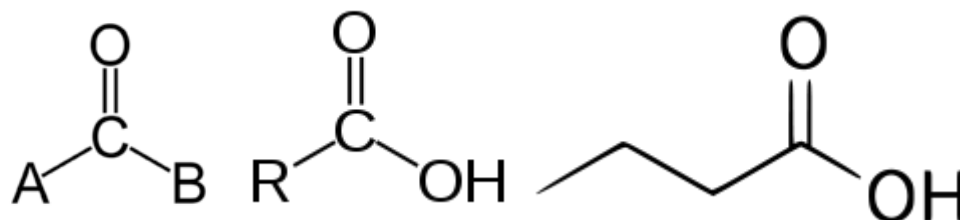


Beta and Omega Oxidation of FA
Thomas Dayspring MD, FACP, FNLA

Fatty acids perform numerous functions in the body. One is to be an oxidative substrate capable of providing energy in the form of adenosine triphosphate (ATP). Fatty acids are carboxylic acids (CA) whose basic form is HO-C=O (CA contain a carbonyl moiety or C=O). The carbonyl moiety is attached to the rest of the FA molecule often labeled as “R” in the written formula. If the –OH moiety is removed, the remaining functional molecule is called an “acyl” group and has the formula R-C=O.



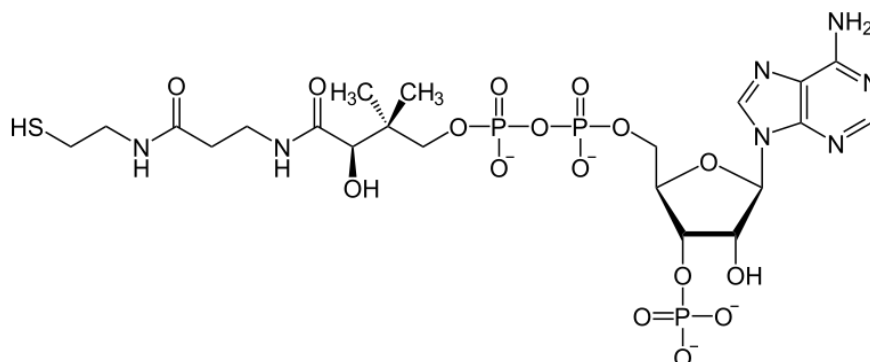
Carbonyl Moiety

Carboxylic acid

Fatty Acid

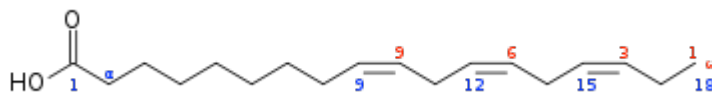
Oxidation is a chemical process involving the loss of electrons of a molecule. Reduction is the gain of electrons. Together they are called redox operations. Substances that can accept electrons are oxidants or said to be oxidative. Substances that donate electrons are reductants. Flavin adenine dinucleotide (FAD), a riboflavin or vitamin B2 moiety, is a redox cofactor involved in several important reactions in metabolism. FAD can exist in two different redox states, which it converts between by accepting or donating electrons.

Oxidation is process by which fatty acids provide energy(literally the burning of fat) in the form of adenosine triphosphate (ATP). There are two types of oxidation, beta and omega. The most prominent method is beta-oxidation which is the process where long chain fatty acids are degraded into shorter and shorter FA all the way to a molecule called acetyl-coenzyme A (acyl CoA). This oxidative process begins with the help of coenzyme A (a coenzyme is a protein to which is attached a nonprotein moiety that enables the enzyme to better perform its function). Coenzymes are “helper molecules.” Coenzyme A is used not only for oxidation or synthesis of fatty acids but also pyruvate in the citric acid cycle and many other cellular reactions. Coenzyme A is a thiol (contains a sulfur or S-H bond) and is a derivative of Vitamin B5.

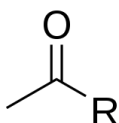


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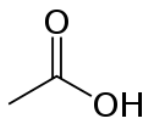
Fatty acids can be numbered counting backwards from their last or terminal carbon molecule (the omega carbon or the n-1 carbon) or by counting forwards from the functional group (carbonyl moiety). The first carbon after the carbonyl moiety (C=O) is called alpha and the second carbon in the FA chain is called the beta carbon.



Beta-oxidation is the process by which FA are broken down by removing the 2nd or beta carbon. Two (2) carbon units are removed sequentially with each cycle of beta-oxidation. Omega oxidation begins at the terminal or omega carbon (it occurs in the endoplasmic reticulum not mitochondria). Omega-oxidation is used by fatty acids of 20 carbon length or more. The ultimate derivative of fatty acid beta-oxidation is a three carbon molecule called acetylCoA which can then “begin life anew” and serve as an acyl donar.

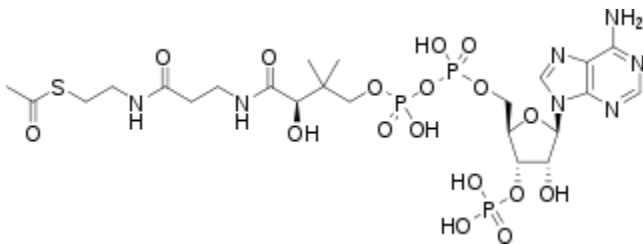


Acetyl Moiety



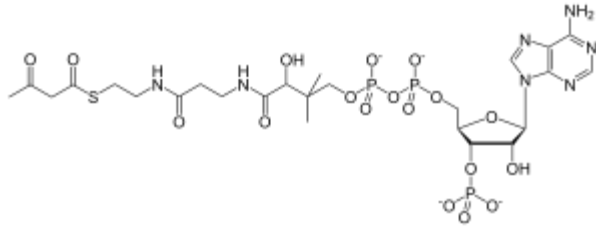
Acetic acid

Acetyl-CoA can be used to convey the carbon atoms within the acetyl group to the citric acid cycle to be oxidized for energy production in the citric acid cycle or can become ketone bodies. It also is used to produce acetylcholine. Or two acetyl-CoA can be condensed to create acetoacetyl-CoA, the first step in the HMG-CoA/ mevalonic acid pathway leading to synthesis of isoprenoids and ultimately cholesterol. Understanding all of that is how one can link extra fatty acid consumption to increased cellular cholesterol. Thus acetyl-CoA is a crucial molecule linking carbohydrate and fatty acid metabolism



Acetyl-CoA

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Acetylacetyl-CoA

One therapeutic benefit of fatty acid oxidation is, if you burn off (oxidize) FA, you lose the substrate required for monoacylglycerol, diacylglycerol and ultimately for triacylglycerol or TG synthesis (glycerides are simply acyl groups added to glycerol). Fibrates, niacin and omega-3 fatty acid supplementation increase beta-oxidation of FA and it is one of the many reasons they inhibit TG synthesis