Lipid Metabolism and Ketogenesis

Lipid metabolism is composed of catabolic processes that generate energy and anabolic processes that create biologically important molecules, such as triglycerides, phospholipids, second messengers, local hormones and ketone bodies. Ketogenesis is the process of breaking down fatty acids in order to produce ketone bodies, such as acetoacetate, acetone, and beta-hydroxybutyrate.



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Lipid Metabolism

Acetyl-CoA
Seagull
Acetyl CoA, or acetyl coenzyme A, is an important molecule that participates in the Krebs Cycle, as well as lipid metabolism. In lipid metabolism, acetyl CoA takes part in a carboxylation reaction with biotin cofactor to produce malonyl-CoA.

Biotin Cofactor
Bionic-tin-man
Biotin is an important cofactor in the carboxylation reaction of acetyl CoA to malonyl-CoA via the transfer a carbon dioxide group.

Malonyl-CoA
Melon
Malonyl-CoA is formed by carboxylating acetyl CoA, and in the process of lipid metabolism, or lipogenesis, malonyl-CoA is used to form fatty acids and triglycerides.

Fatty Acids
Bacon Acid-lemon
Malonyl-CoA is broken down, and used to add to two carbons to a lengthening fatty acid chain. When fatty acid synthesis is complete, these fatty acid chains are combined with glycerol, at the ratio of three fatty acids to one glycerol molecule, to form triglycerides.

Triglycerides
TAG on 3 Bacon wrapped Acid-lemons
When fatty acid synthesis is complete, these fatty acid chains are combined with glycerol, at the ratio of three fatty acids to one glycerol molecule, to form triglycerides.

Glycerol
Glitter-roll
At this stage, glycerol, as well as the three fatty acids, can be stored together as triglycerides in adipose tissue for later energy use, incorporated into very low density lipoproteins (VLDL) and released into the bloodstream for storage in adipose tissue, or they are broken down as a result of lipolysis. Once free from the triglyceride compound, glycerol is then able to enter the gluconeogenesis pathway.

DHAP
Dhapper Dog-in-Hat
In this stage, products of lipid metabolism can be used in the glycolysis pathway. Glycerol is converted to glycerol-3-phosphate, and later to DHAP, or dihydroxyacetone phosphate, which is an intermediate molecule in glycolysis.

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Acetoacetyl-CoA

2 Seagulls together

Acetyl-CoA, instead of using biotin to become malonyl-CoA, can enter an alternative pathway. This is called the mevalonate pathway, and here, acetyl-CoA is converted to acetoacetyl-CoA by the enzyme thiolase. An important distinction to make is that this process does not require a biotin cofactor.

HMG-CoA

Humming-bird with Coin purse

HMG-CoA serves as an intermediary in the mevalonate and ketogenesis pathways. It is derived from acetoacetyl-CoA via the actions of the enzyme HMG-CoA synthase.

HMG-CoA Reductase

Humming-bird with Coin purse and Red-duck

The enzyme HMG-CoA reductase is the rate-controlling enzyme of the mevalonate pathway. The action of this enzyme converts HMG-CoA to mevalonate, and later cholesterol. HMG-CoA reductase is the target of the statin drug class, and these drugs are also called HMG-CoA reductase inhibitors. By inhibiting this enzyme, statins slow the formation of cholesterol.

Mevalonate

My-Valentine

Mevalonate, or mevalonic acid, is formed from HMG-CoA, via the enzyme HMG-CoA reductase. This compound is converted into cholesterol.

Cholesterol

Cholestrol-burger

Cholesterols are formed in the mevalonate pathway, and are synthesized by mevalonate.

Ketogenesis

Acetoacetate

Seagull-ass

HMG-CoA can alternatively enter the ketogenesis pathway, instead of the mevalonate pathway. In ketogenesis, the enzyme HMG-CoA lyase converts HMG-CoA into acetoacetate. Acetoacetate is converted into the ketone bodies, acetone and beta-hydroxybutyrate.

Beta-Hydroxybutyrate

Beta-fish with Water and Butter

Beta-hydroxybutyrate serves as an energy source for the brain when blood glucose is low, and is the product of ketogenesis. The enzyme beta-hydroxybutyrate dehydrogenase forms beta-hydroxybutyrate from acetoacetate.

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