**Evolution of Caffeine Biosynthesis Enzymes**

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**Part 1: How do plants make caffeine?**

Coffee, tea, cocoa, and other caffeine producers make caffeine (1,3,7-trimethixanthine) from the nucleoside metabolite xanthosine through a series of enzymatic reactions. Here we will learn what these enzymes are and how they facilitate caffeine biosynthesis.

The Denoeud et al., 2014 (Science paper) explains that coffee plants have a set of 3 enzymes that convert a xanthosine into caffeine. All three enzymes [*i.e.*, xanthosine methyltransferase (XMT); 7-methylxanthine methyltransferase (MXMT); and 3,7-dimethylxanthine methyltransferase (DXMT)] are N-methyl transferases that use the cofactor S-adenosylmethionine (SAM) as the methyl group donor.

Review the chemical structures of xanthosine, caffeine, and various intermediates in the biosynthetic pathway.



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Q1. The cofactor/co-substrate SAM is used by all the enzymes (XMT, MXMT, and DXMT). In each case at the end of the enzyme reaction SAM is converted to SAH. Can you figure out what SAH is?

*Box 2: Concept*

Enzymes undergo conformational changes in order to catalyze a reaction. Sometimes these changes include movement of loops and also interacting with other molecules (such as cofactors, ions). **Apoenzyme**s – i.e. the enzyme without any substrate, cofactor etc. bound to it, is often **inactive**. Binding to substrate(s) and cofactor(s) can **activate the enzyme** and prepare it to perform the enzyme reaction.

Q2. If you had to assemble an active complex of the XMT enzyme, that is about to perform the catalysis, what molecule(s) would you include in this complex?