Two Cobalt Chelatase Subunits Can Be Generated from a Single chlD Gene via Programed Frameshifting

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Magnesium chelatase chlIDH and cobalt chelatase cobNST enzymes are required for biosynthesis of (bacterio)chlorophyll and cobalamin (vitamin B12), respectively. Each enzyme consists of large, medium, and small subunits. Structural and primary sequence similarities indicate common evolutionary origin of the corresponding subunits. It has been reported earlier that some of vitamin B12 synthesizing organisms utilized unusual cobalt chelatase enzyme consisting of a large cobalt chelatase subunit (cobN) along with a medium (chlD) and a small (chlI) subunits of magnesium chelatase. In attempt to understand the nature of this phenomenon, we analyzed >1,200 diverse genomes of cobalamin and/or chlorophyll producing prokaryotes. We found that, surprisingly, genomes of many cobalamin producers contained cobN and chlD genes only; a small subunit gene was absent. Further on, we have discovered a diverse group of chlD genes with functional programed ribosomal frameshifting signals. Given a high similarity between the small subunit and the N- terminal part of the medium subunit, we proposed that programed translational frameshifting may allow chlD mRNA to produce both subunits. Indeed, in genomes where genes for small subunits were absent, we observed statistically significant enrichment of programed frameshifting signals in chlD genes. Interestingly, the details of the frameshifting mechanisms producing small and medium subunits from a single chlD gene could be prokaryotic taxa specific. All over, this programed frameshifting phenomenon was observed to be highly conserved and present in both bacteria and archaea.

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