Identification and Characterization of Multifunctionality in Escherichia coli K-12 Substr. MG1655

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Abstract
Multifunctional enzymes are enzymes that catalyze more than one reaction. Certain multifunctional enzymes have functions that act in opposition to each other such as forward modification or reverse modification. While in others the two functions represent consecutive enzymatic steps in some metabolic pathways.

To understand very well the second class of multifunctionality, this study was done on Escherichia coli K-12 substr. MG1655. 178 multifunctional enzymes literature-reported were collected and characterized using EcoCyc and BLAST databases. They were further specified in different types of multifunctionality based on whether the reactions they catalyze are sequential or not.

Multifunctional enzymes are not-evenly distributed in species; Bacteria have more multifunctional enzymes than Archaebacteria and Eukaryotes. Comparative analysis indicated that the multifunctional enzymes experienced a fluctuation of gene loss during the evolution from Escherichia coli to H. sapiens.

Results

Figure 1a: The multifunctional enzymes catalyze non-sequential reactions as the picture shows.

Figure 1b: The functions of these multifunctional enzymes represent enzymatic steps in different metabolic pathways. For example FSL, succinyl-CoA synthetase/aminocarboxytransferase is found in both superpathways of arginine and polyamine biodegradation.

Figure 1c: One example of this type of multifunctionality is bifunctional histidine/glutamate synthetase/dihydrolate synthetase in the pathway of bile polyglutamates.

Figure 1d: These multifunctional enzymes catalyze sequential enzymatic steps in a metabolic pathway, 32 of them were found in E. coli.

Background:

Previous research has shown the existence of 6799 multifunctional enzymes in all species. Multifunctionality seems to be a common mechanism of communication and cooperation between different functions and pathways within a complex cellular system or between cells.

They are further specified as promiscuous enzymes or moonlighting enzymes. Promiscuous enzymes are characterized as enzymes of catalytic domains executing several functions. Unlike promiscuous enzymes, moonlighting enzymes are acknowledged to have at least a single catalytic domain and a non-catalytic domain.

Methods:

All data analysis was performed using version 17.1 of the EcoCyc database, released on June 11, 2013. The multifunctional enzymes were manually validated. BLAST2.2.28+ released in April 2013 was used to examine the sequence similarity of the multifunctional enzymes in both E. coli and in Humans.

Conclusion

In our study, multifunctional enzymes in Escherichia coli K-12 substr. MG1655 were characterized and identified; there exist eight different types of multifunctionality based on the reactions they catalyze. Our data show that the multifunctionality can be lost during evolution; some multifunctional enzymes were found in Escherichia coli but not in humans for example pyruvate formate-lyase deactivase was found to be only multifunctional in E. coli, fused heptose 7-phosphate kinase/heptose 1-phosphate adenyltransferase is not bifunctional in higher organisms. Also, the concept of preventing the intermediate from being released into the solution does not apply for all multifunctional enzymes.

References

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