88. Consistent Estimation of Gibbs Energy Using Component Contributions

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Project Goals: The aim of this project was to develop a method for consistent estimation of reaction Gibbs energies in metabolic networks. Reaction Gibbs energies can be used in metabolic modeling for applying thermodynamic constraints on reaction rates, metabolite concentrations and kinetic parameters.

The increasing scope and diversity of metabolic models has led scientists to look for genome-scale solutions that can estimate the standard Gibbs energy of all the reactions in metabolism. Group contribution methods greatly increase coverage, albeit at the price of decreased precision. We present here a way to combine the estimations of group contribution with the more accurate reactant contributions by decomposing each reaction into two parts and applying one of the methods on each of them. This method gives priority to the reactant contributions over group contributions while guaranteeing that all estimations will be consistent, i.e. will not violate the first law of thermodynamics. We show that there is a significant increase in the accuracy of our estimations compared to standard group contribution. Specifically, our cross-validation results show an 80% reduction in the median absolute residual for reactions that can be derived by reactant contributions only. We provide the full framework and source code for deriving estimates of standard reaction Gibbs energy, as well as confidence intervals, and believe this will facilitate the wide use of thermodynamic data for a better understanding of metabolism.

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