Quantification and Classification of E. coli Proteome Utilization and Unused Protein Costs across Environments

The costs and benefits of protein expression are balanced through evolution. Expression of un-utilized protein (that have no benefits in the current environment) incurs a quantifiable fitness costs on cellular growth rates; however, the magnitude and variability of un-utilized protein expression in natural settings is unknown, largely due to the challenge in determining environment-specific proteome utilization. We address this challenge using absolute and global proteomics data combined with a recently developed genome-scale model of Escherichia coli that computes the environment-specific cost and utility of the proteome on a per gene basis. We show that nearly half of the proteome mass is unused in certain environments and accounting for the cost of this unused protein expression explains >95% of the variance in growth rates of Escherichia coli across 16 distinct environments. Furthermore, reduction in unused protein expression is shown to be a common mechanism to increase cellular growth rates in adaptive evolution experiments. Classification of the unused protein reveals that the unused protein encodes several nutrient- and stress- preparedness functions, which may convey fitness benefits in varying environments. Thus, unused protein expression is the source of large and pervasive fitness costs that may provide the benefit of hedging against environmental change.

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