Coupling the Cybernetic Model With Flux Balance Analysis for Dynamic Simulation of Overflow Metabolism in Escherichia coli

Chan, Kiera (School: Staten Island Technical High School)

Metabolism forms the foundation of understanding how cellular processes work; however, not all reactions within a metabolic network are fully understood. Some specific metabolic pathways in different environmental conditions are not shown and this leads to significant information gaps. This research aims to investigate the factors that control Escherichia coli's overflow metabolism called the Crabtree effect in aerobic conditions and specifically investigates the dynamic regulation of energy resources. This was done by applying the novel approach of using the Cybernetic Model (CM) together with Flux Balance Analysis (FBA) to model this metabolic phenomenon accurately and precisely using Python. These methods coupled together compensate for each other's limitations which were used to create a dynamic metabolic model. FBA was used to regulate metabolites within E. coli's core metabolic network and calculated its growth rate with the yields for biomass and acetate at steady state. CM was used to show the dynamic growth and metabolism of E. coli from utilizing glucose and acetate. By comparing model data with experimental data, it was found that they had a t-test p-value > 0.05, R^2 value > 0.99, Spearman coefficient >= 0.98 and Spearman's p-value >= 0.0 which supported that there is a strong positive correlation and no association between the data sets. The Chi-square value >= 0.99 supports that there is a high similarity between the model and experimental data except for the modeling of glucose utilization. This framework can be applied to making predictions for the biotechnological and biopharmaceutical industries.

Awards Won: