

## **ABSTRACT**

The Biocomplexity Project. (April 2001)

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The ultimate goal of the Texas A&M Biocomplexity Project is to numerically and visually simulate a complete chemical mechanism for a simplified cell. It will incorporate the rapidly growing knowledge about cellular components, and will highlight some of the emergent properties arising from the interactions among these components, providing a greater understanding of certain cellular processes. This thesis describes the completed work with which I have been involved in this project, including several related subproblems. A complete set of chemical reactions was written to model selected metabolic and cell-cycle processes in the simplest prokaryotes. A computer program was written to read, analyze, and stochastically simulate such mechanisms, and a 3D computer animation was produced to visualize the cell-cycle reactions. In order to better understand the properties of regulation in a cell, six mechanisms were written and analyzed mathematically. The models examined the effects of negative feedback, cooperativity, oligomerization, transcription, and transcription feedback on the sensitivity of the binding of a protein to its gene and on the range of synthesis and degradation "perturbments" the system could tolerate. A data-fitting program was developed using a searching algorithm known as simulated annealing in order to find values of rate constants that best fit data for the desired realistic behavior of the mechanical cell. This algorithm was used to fit experimental data involving the enzyme acetyl CoA synthase (which is present in simple chemoautotrophic prokaryotes) to mechanistic models. Therefore, the groundwork has been laid for the project. An initial mechanism has been written, a program is available to simulate it, regulatory mechanisms are better understood, and a method to fit concentration data has been established. The next step is to divide the system into modules, incorporating the best regulatory mechanisms, and to fit each model to realistic data and link the solved, regulated modules into a complete system.