CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Andrew Q. Ninh

Project Number

S1209

Project Title

Two Discrete Stochastic Cellular Automata Models of Cancer Stem Cell Proliferation

Abstract

Objectives/Goals

The objective was to try to create a general model (using set parameters) of cancer stem cell (CSC) induced tumor growth by combining discrete mathematical models, automata theory, and principles of cellular automaton to create a Java program. This program would in turn produce both custom mathematical models as well as growth visualizations.

Methods/Materials

The mass-action and spatial discrete mathematical models and CSC automata theory were turned into a Java program (on the BlueJ IDE) which models CSC growth, which was graphed on Mathematica. Visual depictions of the automata arrays of the mass-action and spatial Turing machines were created using Mathematica's ArrayPlot function.

Results

After results were averaged from thousands of trials using the law of large numbers, the differentiated cancer cell populations followed the standard Gompertzian growth curve with the mass-action model reaching a lower carrying capacity at a faster rate while the spatial model reached a higher carrying capacity at a slower rate; the cancer progenitor cells exhibited a gradual Gompertzian growth curve; and the CSCs remained at a lifelike percentage of total cells and exhibited a von Bertalanffy growth curve.

Conclusions/Discussion

Cellular automaton, discrete mathematical models, theoretical computer science, and programming was used in creating mathematical models as well as automaton visualization of the progression of solid CSC-induced tumor growth over time. Automata-based modeling of tumors is useful in that automaton "rules" may be potentially substituted by boolean structures of genes, thus bridging bioinformatics and individualized tumor modeling.

Summary Statement

Cancer stem cell (CSC) induced tumor growth is modeled using theoretical computer science and the tumor growth is visualized using cellular automata, potentially helping with creating individualized models of csc-induced tumors.

Help Received

Professor Komarova of UC Irvine introduced me to the mass-action and spatial models (which I used in a different project) that I applied in my research.