CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Steven M. Wang

Project Number

S0528

Project Title

Anti-Tumor Immunity: A Novel Hybrid Cellular Automaton for Cancer Vaccines

Abstract

Objectives/Goals

Cancer vaccines boost immunity, the natural ability of the human body to destroy cancer as Hepatitis B vaccine greatly reduces liver cancer incidence worldwide. As advanced technology rapidly accumulates biological data, researchers employ computational modeling to streamline experiments, understand how cancers progress, and predict patient prognosis and treatment. The purpose of my research is to determine if a preventative cancer vaccine can deliver significant anti-tumor immunity to eliminate an early developing breast cancer. I hypothesize that a novel 3-D hybrid cellular automaton model can be designed to quantify cytotoxic T lympohcytes (CTL) concentration required for anti-tumor immunity and incorporate genetic mutations to accelerate tumor growth.

Methods/Materials

I created computer modeling algorithms using Matlab and Mathematica to analyze interactions between a developing, mutating tumor with blood supply and immune system starting with one cell and growing to quantities of hundreds to thousands of cancer cells, below 100,000 cell mammogram limit. A 3-D hybrid cellular automaton (CA) was designed for cell behavior and partial differential equations (PDE) for chemical diffusion to test spatio-temporal dynamics of 17 control parameters and 5 variables. Driver mutation rates incorporated. Exploring passenger mutation rates. Spearman rank-order correlations calculated. The research applies breast cancer sequencing data and findings from published experimental studies.

Results

A cancer vaccine can provide protective immunity against an early breast cancer with anti-tumor CTL concentrations of 3%, 7%, and 10% for eradicating a tumor in 120 days, 45 days, and 25 days. Tumors totaled 60 tumor cells after 25 days while 1-hit, 2-hit, and 3-hit models of carcinogenesis totaled 225, 300, and 1,300 cells, respectively. Increasing driver mutations increased tumor cell proliferation.

Conclusions/Discussion

New computational model accurately predicted CTLs, results corroborated with in vivo experiments of cancer vaccine activated T cell responses for tumor eradication and CTL, mutations and growth rates are critical to vaccine development and protocol.

Summary Statement

I designed a new 3-D hybrid cellular automaton to analyze tumor- immune system interactions, incorporate genetic mutations, and measure the effect of mutation rate on tumor growth.

Help Received

Sought advice from Dr. Kim, Dr. Lee, Dr. Wije, Dr. Blickenstaff, and others.