Harvey Mudd College
Mathematics

Senior Thesis
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Research Proposal: Mathematical Modeling of Immune-Cancer Interactions

Ben Fogelson

Faculty Advisor: Professor L. G. de Pillis

1 Introduction

The interactions between malignant cells and the cells of the immune system are both complex and not very well understood. Although mathematical models of cancer are a large subfield of mathematical biology, there is still much to be learned by applying mathematical techniques to gain understanding about biological systems that cannot be directly observed. This research will apply techniques from mathematics to gain insight into the complexities of immune-cancer dynamics.

2 Proposed Research

My thesis will investigate and attempt to mathematically model the details of how the immune system can interact with cancer. The specific mathematical techniques applied will be informed by the biological literature, but are likely to include a dynamical system type approach (ordinary or delay differential equations) to modeling the immune and tumor populations, and could also include the use of partial differential equations to model spatial heterogeneities in the biological system.

Once a model is created it will be explored using numerical techniques (requiring that I find biologically relevant parameter values in the literature) and analytical techniques such as bifurcation, fixed-point, and steady state analysis. Hopefully I will be able to use this analysis to validate my model against observations in the literature, and to offer a possible biological mechanism behind those observations.

3 Prior Research

My relevant coursework includes core math, Numerical Analysis, Dynamical Systems (audited), Mathematical Biology I and II (audited), Linear Partial

Differential Equations (at the University of Utah), Partial Differential Equations, and Graduate Partial Differential Equations.

I have prior research in mathematical biology through two VIGRE REUs at the University of Utah modeling the signal transduction events involved in the formation of heart valves in embryogenesis. This is not directly related to modeling cancer but is valuable experience in mathematical biology research..

I will be conducting research with Professor de Pillis this summer on the interactions between cancer and the immune system.

The references section gives a selected list of the readings I have done so far on this topic.

References

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[2] Martinis, M., Vitale, B., Zlatic, V., Dobrosevic, B., Dodig, K. *Mathematical model of B-cell chronic lymphocytic leukemia*, Period. Biol., 107 (2005) pp. 445-450.

[3] de Pillis, L. G., Radunskaya, A.E., Wiseman, C.L. *A validated mathematical model of cell-mediated immune response to tumor growth*, Cancer Res., 65 (2005) pp. 7950-7958.

[4] DeConde, R., Kim, P.S., Levy, D., Lee, P.P., *Post-transplantation dynamics of the immune response to chronic myelogenous leukemia*, J. Theor. Biol., 236 (2005) pp.. 39–59.