Cell Transplantation

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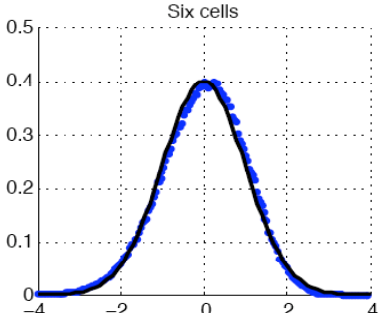
Cell Transplantation is one particular application of tissue engineering that aims to accelerate the growth of new tissue. It involves seeding an artificial, three-dimensional scaffold with cells and cell growth related molecules before culturing and implanting it into a patient in a region where accelerated tissue growth is needed.

The success of Cell Transplantation relies heavily upon the rate and extent of cell proliferation occurring inside the implanted scaffold. Therefore it is important to seed the scaffold in such a way as to encourage the most proliferation.

This idea prompted our Summer Vacation investigation into finding the optimal density of cells originally seeded into a scaffold to promote the greatest amount of proliferation.

It was our aim to develop a discrete model in Matlab capable of replicating cell proliferation in a scaffold given a certain initial cell seeding density and also to use this to find the optimal seeding density. However rather than model a three-dimensional scaffold, which is highly complicated, initially a one-dimensional scaffold was investigated with the hope that it would aid in the study of higher-dimensional scaffolds.

The one-dimensional scaffold was first investigated as an infinite line on the x-axis before being investigated as a semi-infinite and then finite line with and without blocks. The model was based on the idea that at any particular time *T*, where *T* is an integer, given that *z* cells were present at T=0, there were $N_z(T)$ cells present on the line. Also that during a time step *T*, all of the $N_z(T)$ cells present on the line were given the opportunity to proliferate according to a proliferation rule (pictured below). Once this proliferation occurred, the system advanced to time step *T+1* and the number of cells was updated to $N_z(T+1)$.



Using this model, we discovered some interesting things including that as *z* increases, the frequency $f(N_z(T))$ of obtaining $N_z(T)$ cells by a time T, was distributed normally. We confirmed this by first standardizing $f(N_z(T))$, which involved determining the mean μ and standard deviation σ of $N_z(T)$ and using the formula

$$f_s((N_z(T) - \mu)/\sigma) = \sigma f(N_z(T))$$

before comparing f_s with the normal distribution *PDF*. (*z=6* pictured above. Blue dots: simulation results, Black line: normal *PDF*)

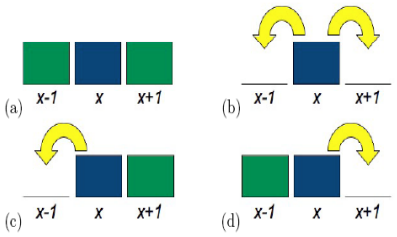


Figure 1: Proliferation rules for the discrete model. (a) Abort proliferation. (b) Proliferate in either direction. (c) Proliferate left. (d) Proliferate right. In all figures the the blue cell represents the selected cell and the green represent the selected cell's neighbours.

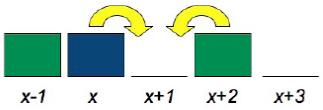


Figure 2: Special case of the proliferation rules during proliferation $T = 0$.

I found the vacation scholarship program invaluable not only because I got to experience research for the first time but also because I was able to learn new skills, including programming and because it made me more aware of the how mathematics can be applied and contribute to the understanding of a vast array of real world applications.

Rebecca was an AMSI/MASCOS Vacation Scholar for 2007-8