Project: A Simulation of Viral Spread

Team name: Umbrella Corporation

Team members: Tao Luo, Lu Qiao, I-Shu Wang, Howard Wu

Objectives

In this project, we will build models to simulate viral spread within a host over a certain period of time via two different methods: cell-to-cell transmission and cell-free transmission. We will also consider the condition if an antiviral drug/therapy is present to stall the spread. In the end, we will visualize our findings from the different conditions we simulate.

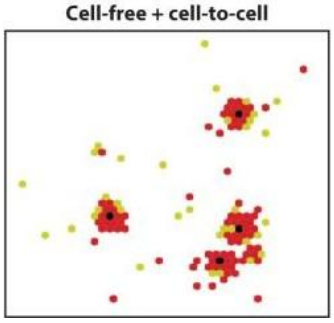

Figure 1: Viral spread simulation (citation: Modeling Viral Spread - PMC (nih.gov))

Why Interesting

During the pandemic, many scientists modeled the spread of viruses worldwide, which is a macroscopic approach. Here, we are interested in the microscopic level, studying how viruses spread in the host cells. Such a simulation is useful to better understand viral infection in order to come up with more effective strategies to defeat viruses. On the other hand, our model could also evaluate the effect of antiviral drugs based on the different severeness of viral infection.

Proposed Model

(Citation: Modeling Viral Spread - PMC (nih.gov))
Cell-to-cell transmission and cell-free transmission (untreated or treated):

The model describes the changing rates of concentrations of target cells (***T***), infected cells (***I***), and virions (***V***) over time. Target cells, ***T***, which are cells susceptible to infection, are produced at a constant rate λ and have an average lifetime of $1/dT$. Infected cells, ***I***, die with rate δ per cell and produce new virions at rate ρ that are cleared from the system at rate ***c*** per virion. In the formulation given, infection of target cells is mediated (a) by cell-free virions at a rate dependent on the viral concentration, ***V***, and a transmission rate constant β and (b) by infected cells with a cell-to-cell transmission rate constant ω. When cell-to-cell transmission is included in the model, virus spread and target cell depletion are accelerated. While the infection is treated

with antiviral therapy, $\boldsymbol{\varepsilon}$, which denotes the drug effectiveness factor, will take effect in the equation with $\boldsymbol{\varepsilon}$=1 corresponding to 100% effectiveness.

$$\begin{cases} \frac{dT}{dt} = \lambda - \beta VT - \omega IT - d_T T \\ \frac{dI}{dt} = \beta VT + \omega IT - \delta I \\ \frac{dV}{dt} = \rho I - cV \end{cases}$$

Cell-to-cell + cell-free (untreated)

$$\begin{cases} \frac{dT}{dt} = \lambda - \beta VT - \omega IT - d_T T \\ \frac{dI}{dt} = \beta VT + \omega IT - \delta I \\ \frac{dV}{dt} = (1-\rho)\varepsilon I - cV \end{cases}$$

Cell-to-cell + cell-free (treated)

Programming for Scientists

Project Team Contract

Team Name: Umbrella Corporation Date: 10/25/2022

GOALS: What are our team goals for this project?
What do we want to accomplish? What skills do we want to develop or refine?

Goal:

- Build the model
- Design cool visual representations of our model
- Deliver an interesting presentation

Skills to develop and refine:

- Coding in Go
- Objective oriented programing
- Recruit the concept of pointers and recursion
- Programming in a top-down approach

EXPECTATIONS: What do we expect of one another in regard to attendance at meetings, participation, frequency of communication, the quality of work, etc.?

1. We expect everyone to attend the weekly meeting and finish the assigned work from the previous week.
2. We will evenly split the work while we finish the assignments.
3. We expect everyone to understand and agree on every aspect of the model, even if they are not the one who drafted the part.
4. After finishing the draft for each assignment (proposal, code, presentation, etc), we should check each other's work, and provide suggestions.

POLICIES & PROCEDURES: What rules can we agree on to help us meet our goals and expectations?

1. Regular weekly meeting: Tuesday 10:00am
    a. Excuses allowed, but please inform team members ahead of time.
2. Follow the Project Guideline while writing codes and essays.
3. Don't hesitate to discuss problems related to the project during regular hours.

4. Response to teammates as soon as possible during regular hours.
CONSEQUENCES: How will we address non-performance in regard to these goals, expectations, policies and procedures?
1. Get milk teas for team members. 2. Get back to work and fix the issues.

We share these goals and expectations, and agree to these policies, procedures, and consequences.

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