

Modeling the Effects of HIV on the Evolution of Diseases

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DIMACS REU

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Motivating Questions

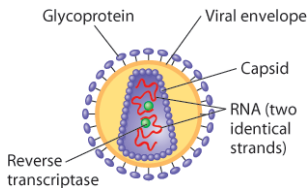
- ▶ How does the presence of HIV in the body changes the evolution of pathogens in the human body?
- ▶ How do different strains emerge at different levels of AIDS prevalence in a population?

Project for the Summer

- ▶ AIDS changes the evolutionary and ecological context for other diseases
- ▶ Current models exist for HIV infection and HIV strain mutations
- ▶ Very few models explore how HIV affects the evolution and mutation of *other* diseases

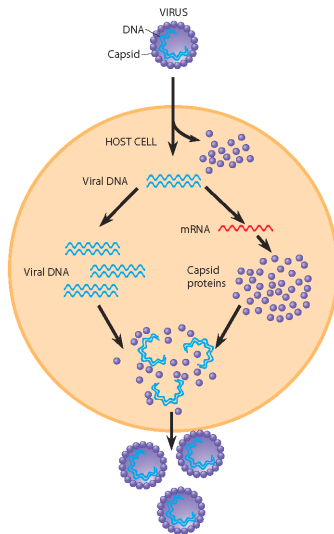
Human Immunodeficiency Virus (HIV)

- ▶ Virus that causes *acquired immunodeficiency syndrome* (AIDS)
- ▶ HIV damages the human immune system by infecting and kill T cells
 - ▶ Causes the body to lose cell-mediated immunity
 - ▶ Death due to other opportunistic infections



HIV

- ▶ The virus enters the host cell and causes the cell to produce new viruses
- ▶ This process is error-prone and can result in new strains of viruses
- ▶ With HIV, the host cell (i.e. T cells) is killed, reducing the ability to fight infection



Looking at the Individual

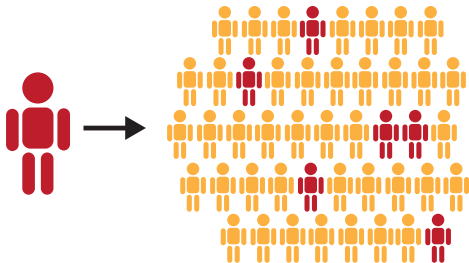
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Summer Project

- ▶ Increased number of cells supporting viral replication due to HIV increases the rate of mutation other pathogens within each person
- ▶ How does HIV infection in a person affect strain competition of another disease?

Looking at the Population

- ▶ Changes in the individual changes the way strain competition occurs within a population
- ▶ How do different strains emerge from different levels of AIDS prevalence in a population?



HIV Infection Model

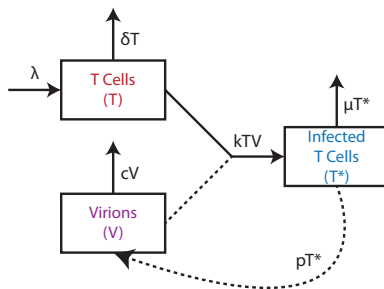
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Introduction

Summer Project

Previous Work



$$\begin{aligned}\frac{dT}{dt} &= \lambda - \delta T - kTV \\ \frac{dT^*}{dt} &= kTV - \mu T^* \\ \frac{dV}{dt} &= pT^* - cV\end{aligned}$$

- Described in Nowak and May, 2000

HIV Competition Model

- ▶ Model developed by Ball et. al. 2007
- ▶ M number of HIV strains labeled as $V_1, V_2, \dots, V_M$
- ▶ ϵ represents the rate of mutation that produces viable mutants

$$\frac{dT}{dt} = \lambda - \delta T - kT \sum_{j=1}^M V_j$$

$$\frac{dT_i^*}{dt} = k(1 - \epsilon) T V_i - \mu(p_i) T_i^* + \frac{\epsilon k T}{M} \sum_{j=1}^M V_j$$

$$\frac{dV_i}{dt} = p_i T_i^* - c V_i, \quad i = 1, 2, \dots, M$$

Goals

- ▶ To develop a model explore how HIV/AIDS affects the evolution and mutation of strains of common and important diseases
- ▶ To model at both the individual and population level
- ▶ To use the model to answer important epidemiological questions

Questions?