Genomic Data-Guided Mathematical Modeling of Cancer

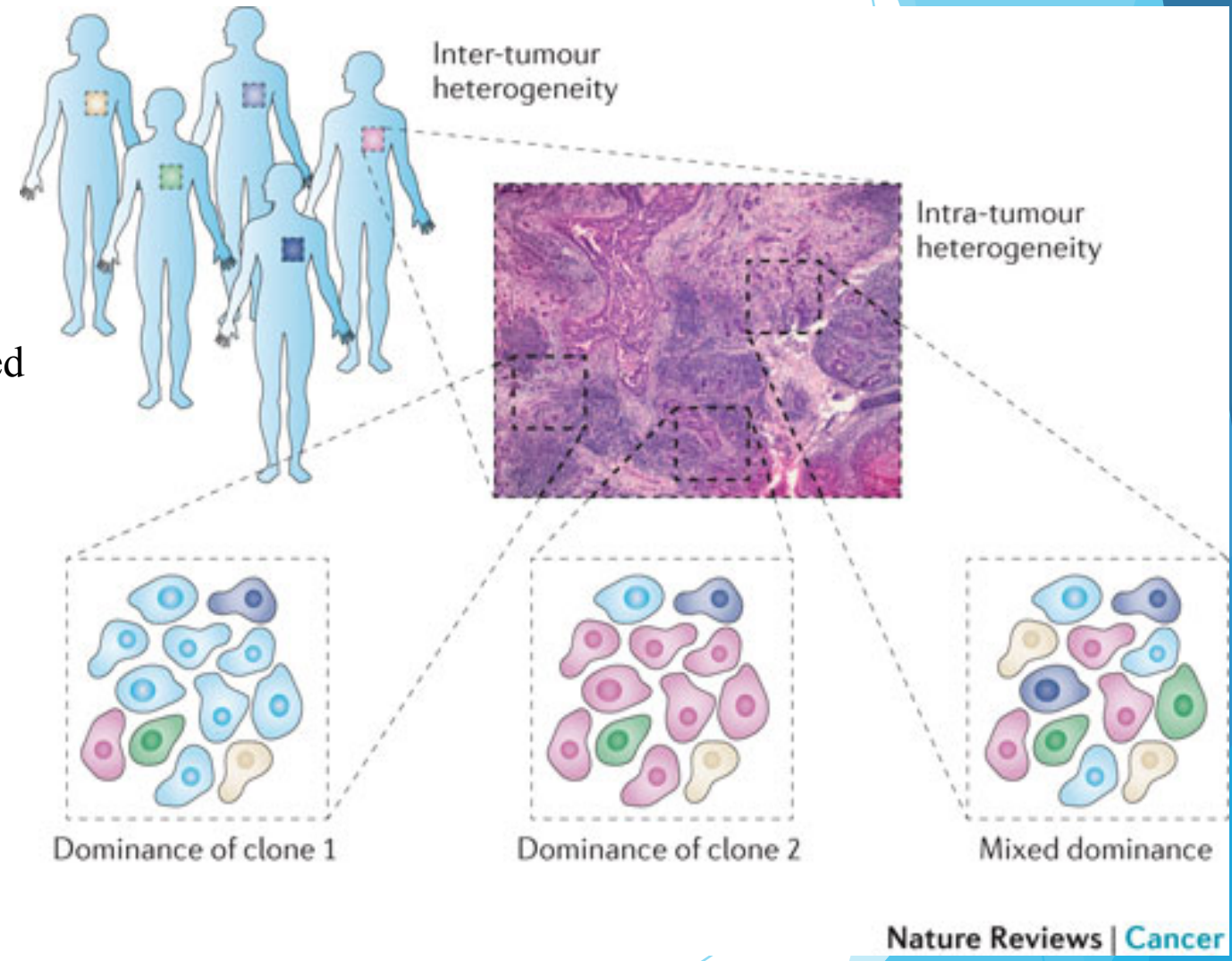
Roxanne Casio – Rutgers University

Prof. De – Cancer Institute of New Jersey

Introduction

- **Cancer**: The uncontrolled growth of abnormal cells in the body.
- It is the second leading cause of deaths in the US.
- In 2014, 2,626,418 deaths were recorded and 22.5 % of these deaths can be attributed to cancer.

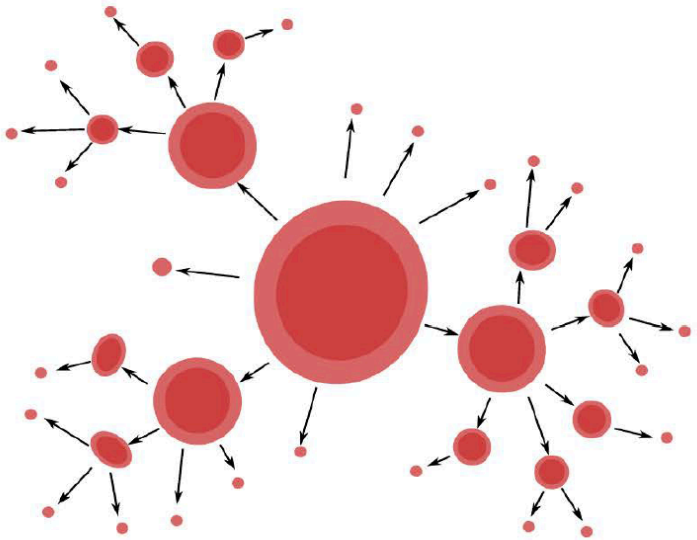
- **Intra-tumor heterogeneity** causes:
  1. Spatial restrictions
  2. Composition restrictions
- Diagnoses depend heavily on biopsies, which may/may not accurately reflect the tumor as a whole.



Models Used

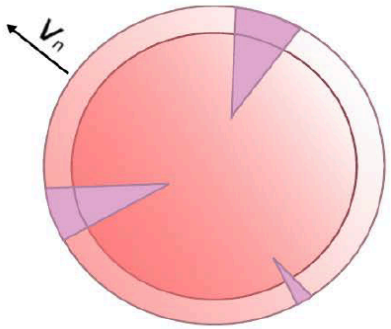
- Based on model and method from Waclaw (2016)

A



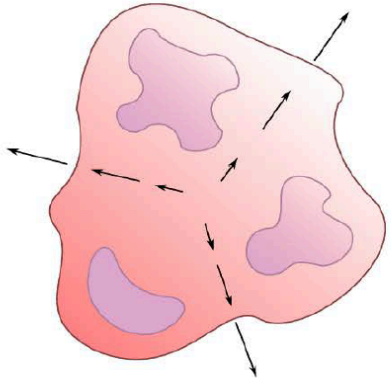
A. Tumor composed of discrete microlesions.
The microlesions:
1. Increase in size
2. Seed other microlesions

B



B. Surface Growth. Only a layer on the surface of the cell replicates radially outward.

C



C. Volumetric Growth. Every cell replicates and pushes outward.

Formulas Used

General Formula:

$V_{tot}(t)$ Total volume of the tumor

$$V_{\text{tot}}(t) = \sum_{n=1}^{\infty} \int_0^{\infty} f_n(a, t) V_n(a) da,$$

n(t) Average number of drivers per cell

$$\langle n(t) \rangle = \frac{1}{V_{\text{tot}}(t)} \sum_{n=1}^{\infty} n \int_0^{\infty} f_n(a, t) V_n(a) da.$$

In the case of single-driver surface growth,

$$V_{tot}(t) = \frac{1}{3M} e^{Gt} + \frac{2}{3M} e^{\frac{-Gt}{2}} \cos\left(\frac{\sqrt{3}}{2} Gt\right) - \frac{1}{M},$$

Where:

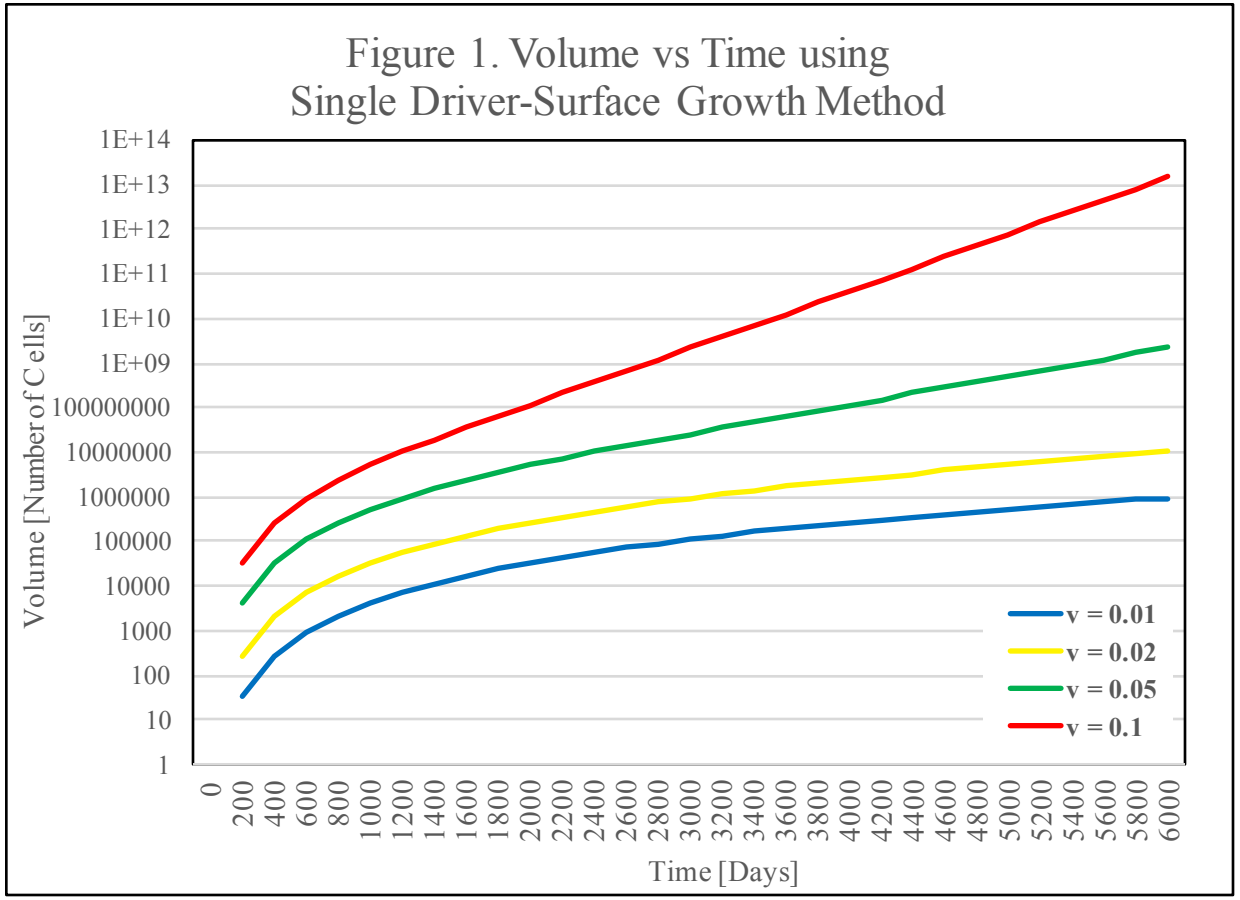
$f_n(a,t)$: The expected number of microlesions of age a at time t

$V_n(a)$: Total volume of a microlesion of type *n* at age a

G: Asymptotic growth rate

M: Migration Probability

Results Produced



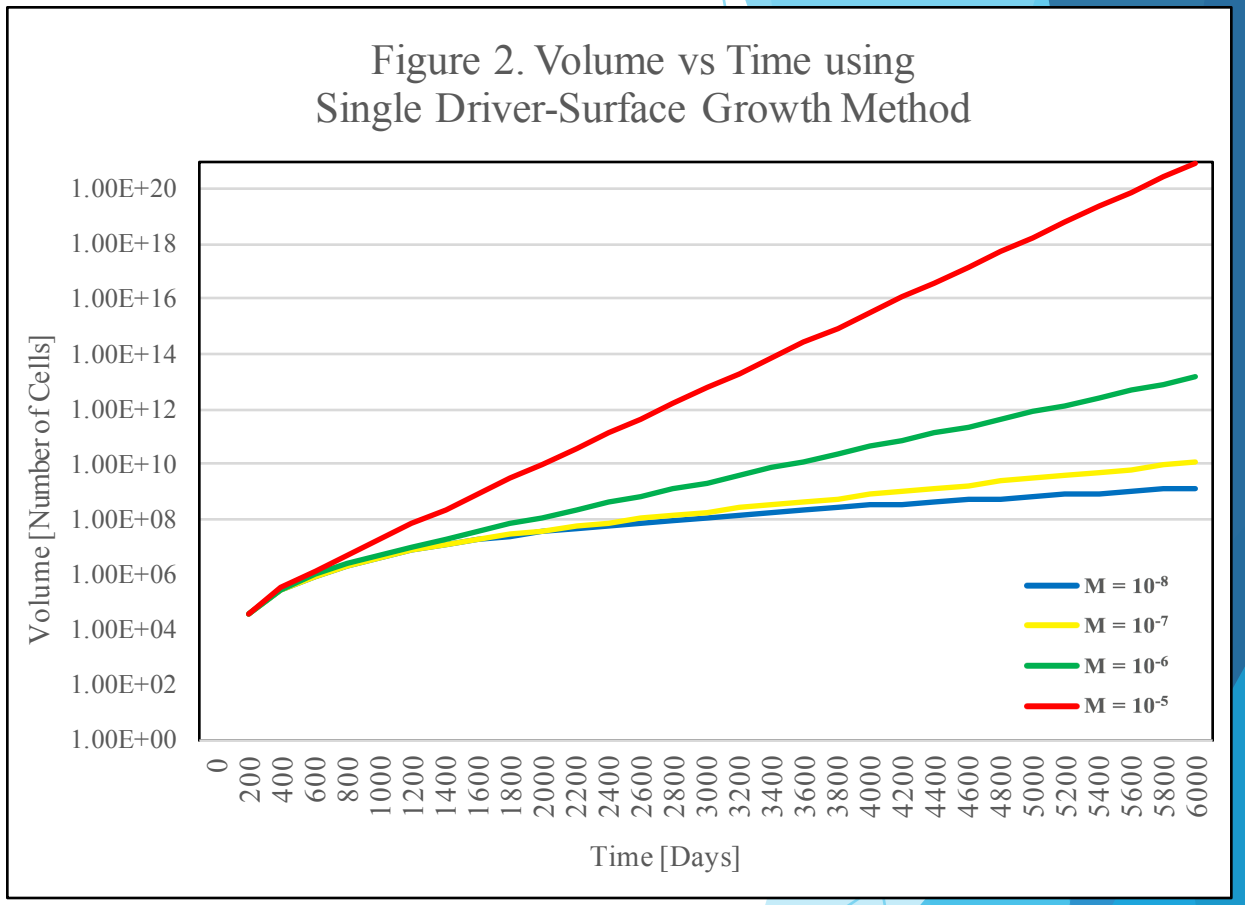


Figure 1. Using the single driver-surface growth method. Figure 1 is a plot of the relationship between volume and time when **velocities vary** and **migration probability is constant**.

Figure 2. Using the single driver-surface growth method. Figure 2 is a plot of the relationship between volume and time when **migration probabilities vary** and **velocity is constant**.

Results Produced

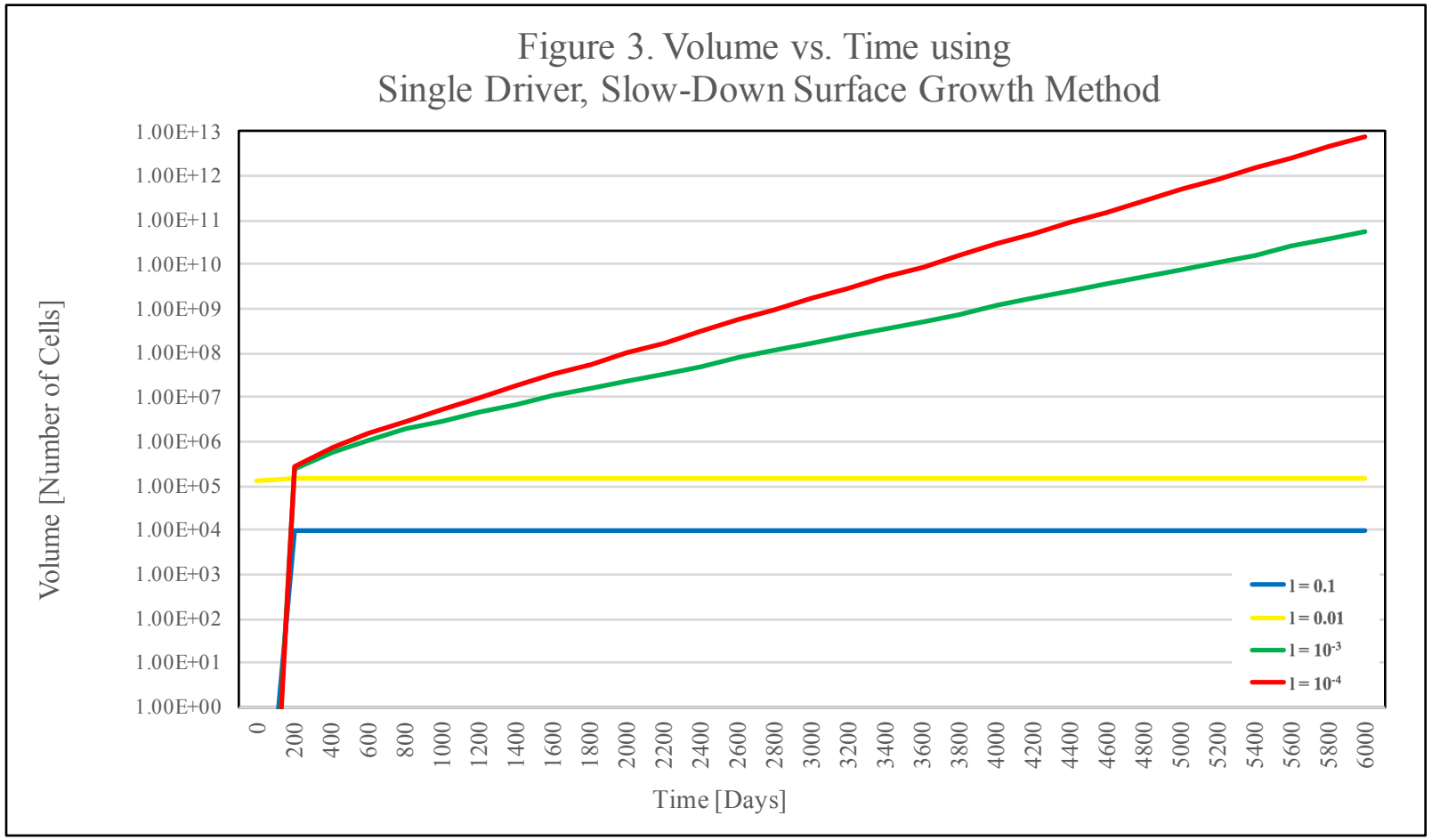
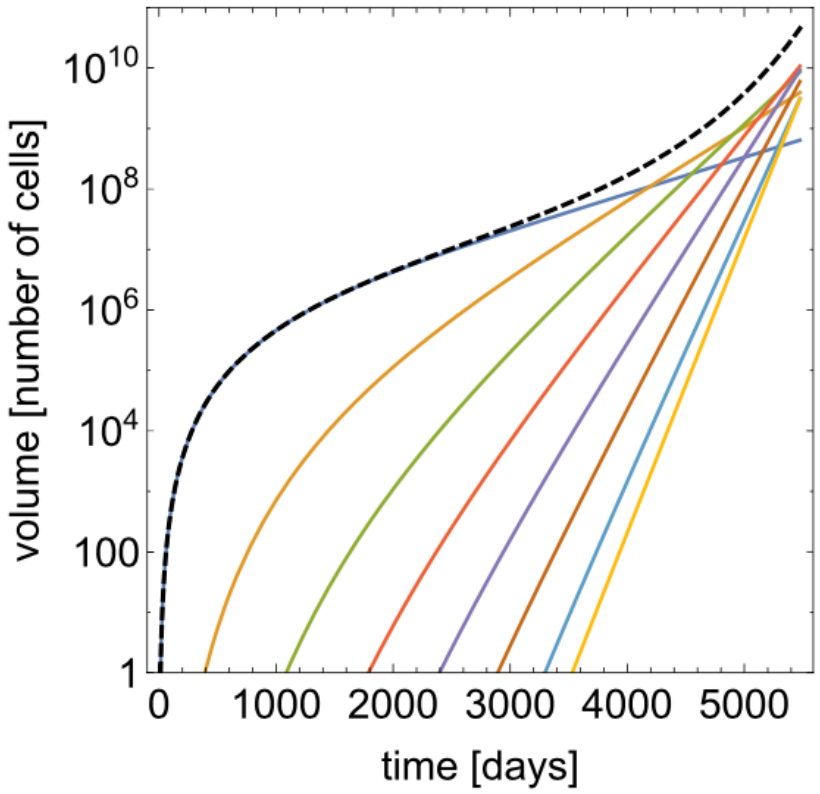
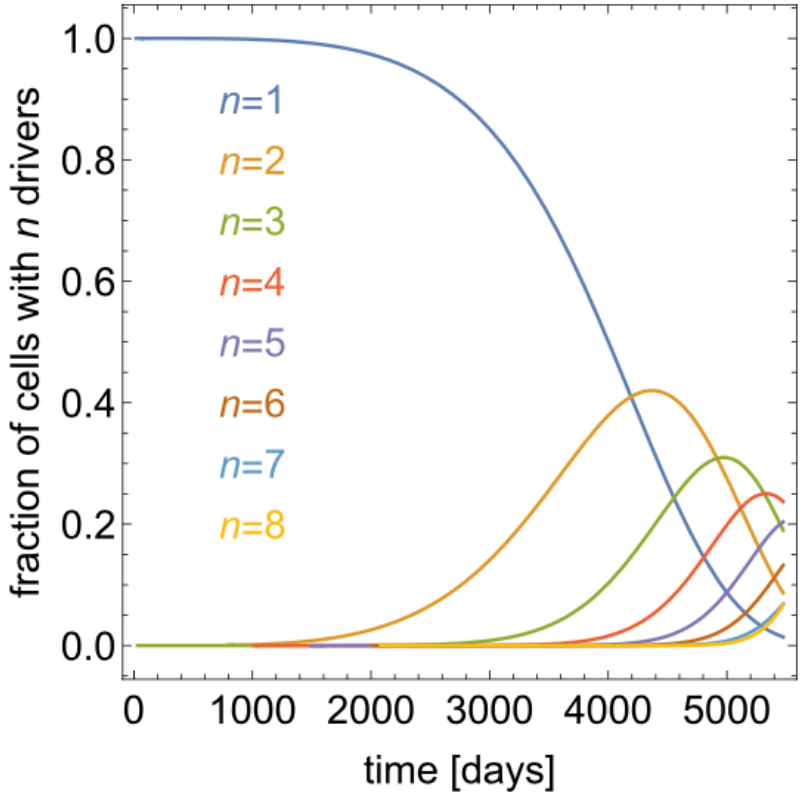


Figure 3. Using the single driver-slow-down surface growth method.

Figure 3 is a plot of the relationship between volume and time with **constant migration probability**, **constant velocity**, and **varying time scales of growth decrease**.

Work in Progress

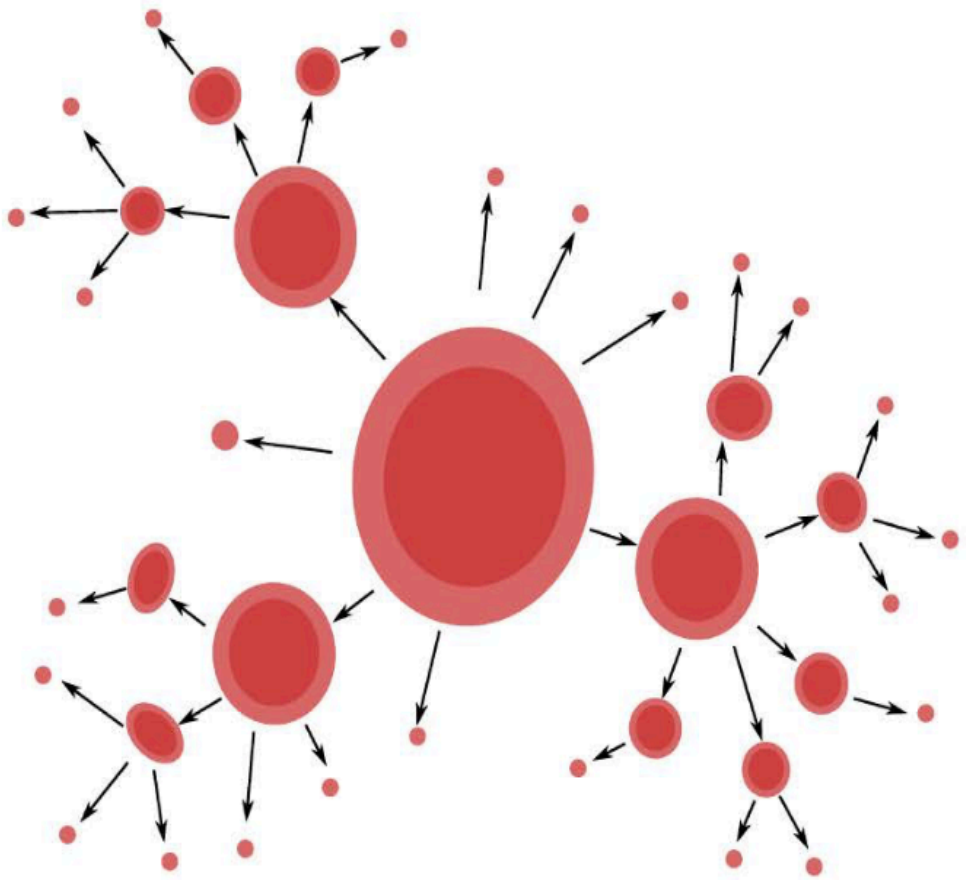


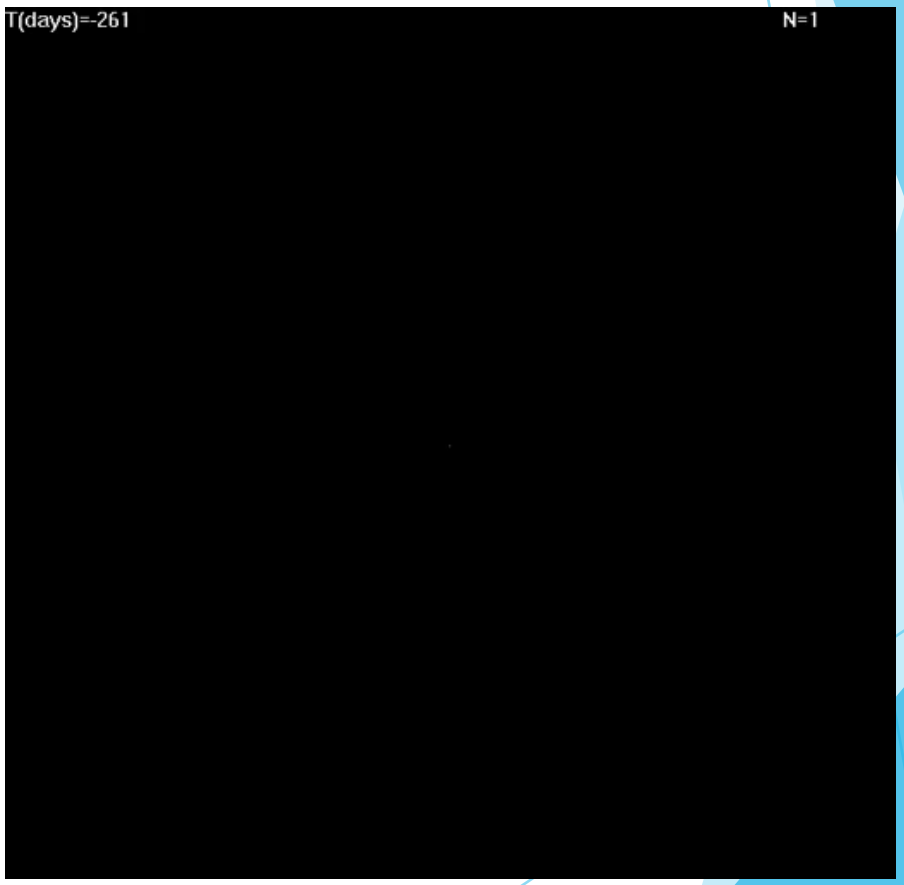


- Total volume and fraction of cells with *n* drivers in the case of surface growth.
- Colored lines represent subpopulations of cells within a tumor with *n* number of mutations.

Future Plan

- Research on cancer growth is limited to 2D.
- 3D models of tumors, today, do not accurately represent the true nature of the tumor.





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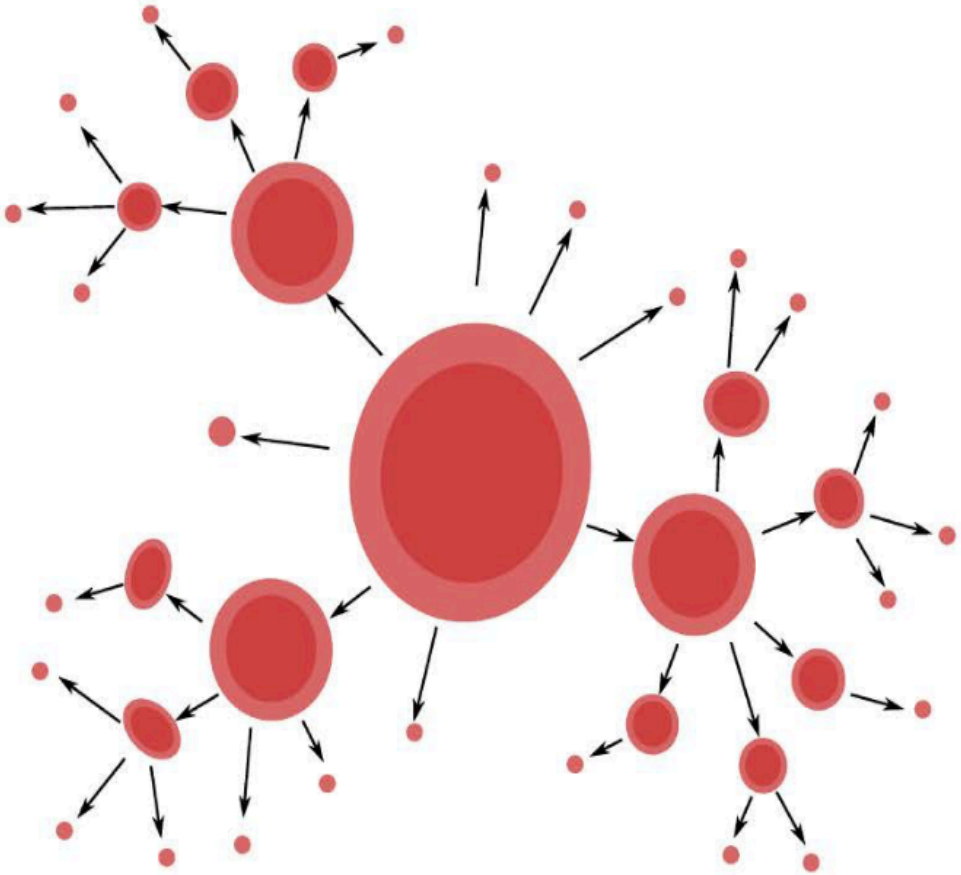

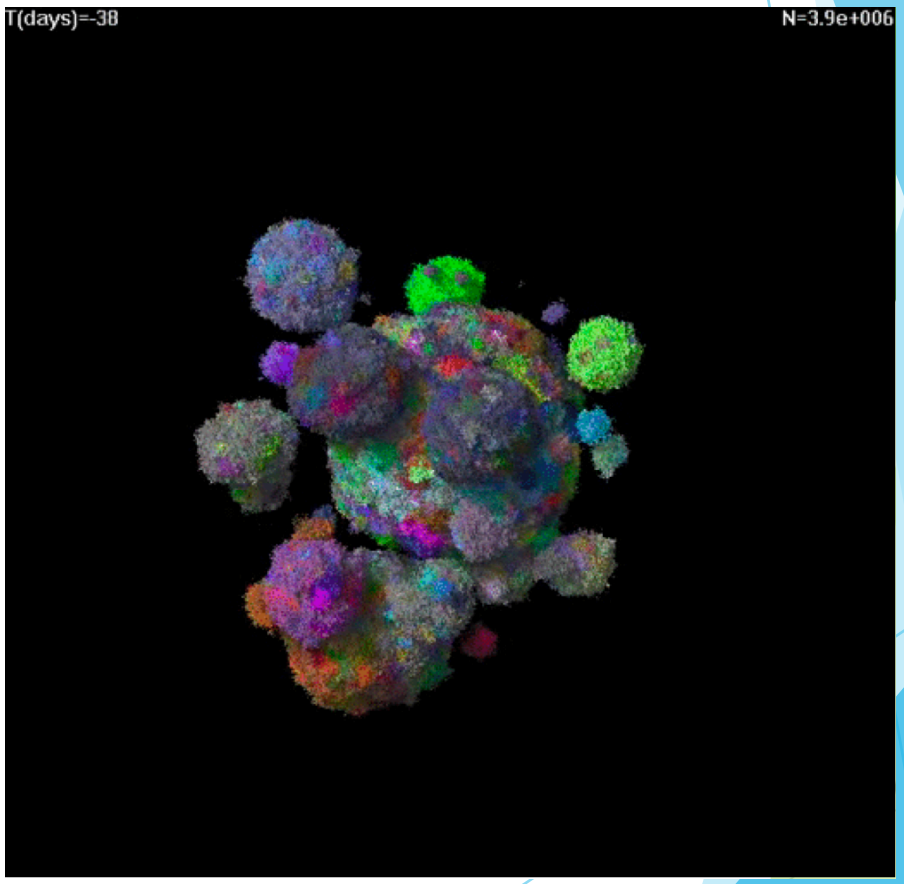

Acknowledgements

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Works Cited

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