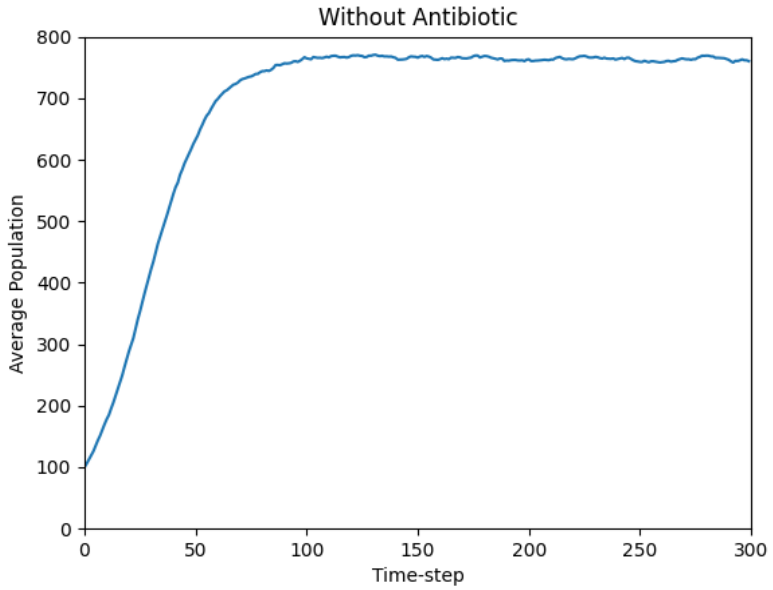
Gabriel Munoz - Tuesday, August 3, 2021

Problem Set 4: Simulating the Spread of Disease and Bacteria Population

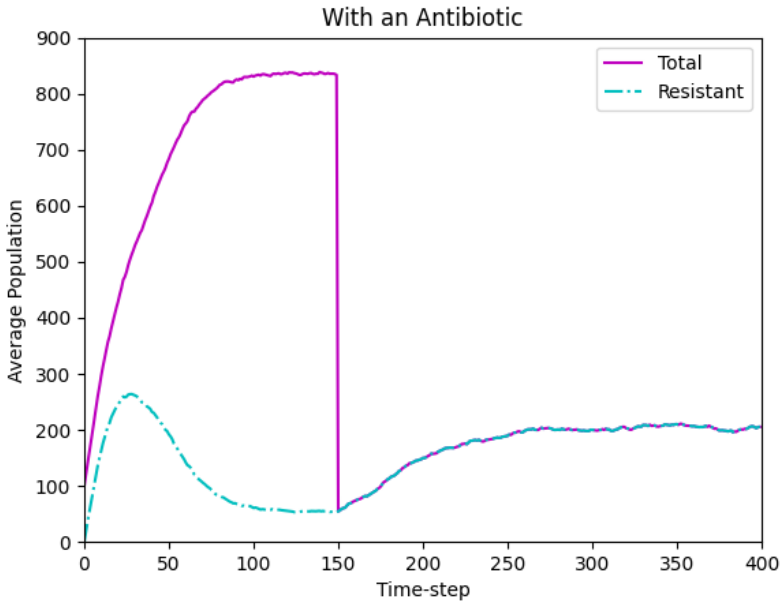
Problem 6: Write-up

Problem 2 Simulation Graph



Problem 5 Simulation Graphs

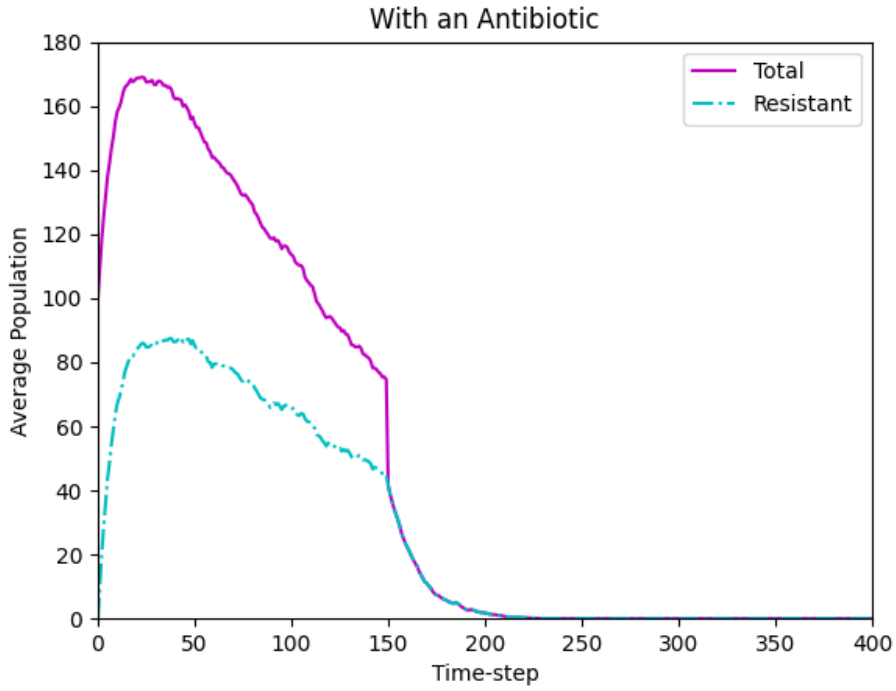
Simulation A:



Trends of Simulation A

1. What happens to the total population before introducing the antibiotic?
    a. *The total population increases dramatically, but as time passes, the rate of change decreases until it reaches an asymptote at its max, at time-step=150.*
2. What happens to the resistant bacteria population before introducing the antibiotic?
    a. *The resistant bacteria population increases at a rapid rate, reaches its maximum very quickly, and then begins to gradually decrease until it hits its minimum. It then begins increasing again, gradually, right before time-step=150, when the antibiotic is introduced.*
3. What happens to the total population after introducing the antibiotic?
    a. *After introducing the antibiotic to the total population, the total population instantly plummets (most bacteria are killed), reaches its minimum, and then begins to increase once again at a slow, but steady pace.*
4. What happens to the resistant bacteria population after introducing the antibiotic?
    a. *The resistant bacteria population begins increasing again, at a faster rate (identical to that of the total population after this time-step=150).*

Simulation B:



Trends of Simulation B

1. What happens to the total population before introducing the antibiotic?
    a. *The total population increases dramatically very fast and reaches its max. Then it begins to decrease sharply until at time-step=150 the antibiotic is introduced.*
2. What happens to the resistant bacteria population before introducing the antibiotic?
    a. *The resistant bacteria population also increases dramatically, reaches a maximum, then starts decreasing steadily until time-step=150.*
3. What happens to the total population after introducing the antibiotic?
    a. *Once the antibiotic is introduced, the total population plummets (bacteria killed), nearly to half of what it was the previous instant, before it decreases more slowly and asymptotically approaches 0 only a few dozen time-steps after.*
4. What happens to the resistant bacteria population after introducing the antibiotic?
    a. *The resistant bacteria population also decreases sharply once the antibiotic is introduced, but not quite as much as the total population does at time-step=150. Immediately following time-step=150, the resistant bacteria decreases identically to the total population.*

The difference between Simulation A and B…

...the birth probability for Simulation A is 30% and 17% for Simulation B. This explains the roughly 5 times greater max total population for A compared to B. The trend for Simulation B in which the total population begins decreasing long before the antibiotic is introduced is explained by the birth probability of almost half of what it was for A. This also explains the fact that once the populations reach the low figures with the antibiotic introduced, there just isn't enough of a survival rate for the bacteria to remain (because of a low birth rate, bacteria are less likely to pass on their resistance to the antibiotic, if they have it). Finally, the immense decrease in the total bacteria population in A is due to the close to maximum population density, which makes bacteria reproduction--and hence mutation and inheritance of the antibiotic resistance--extremely unlikely, and hence a small fraction of the bacteria survive once the antibiotic is introduced.