June 10 REU Talk

Simulating Antibiotic Resistant Bacteria Populations

Recap

- Last week I explained that the goal of our project is to simulate population dynamics of bacteria.
- We look at two populations living side-by-side, one that's susceptible to antibiotics and one that's resistant
- Both populations have constant birth rates, but the resistant population reproduces slightly more slowly.
- In addition, there's a low transformation rate at which susceptible bacteria can acquire plasmids from their environment and transform into resistant bacteria.

Finished work

- Want to explore parameter space to see how the population dynamics change for different combinations of these parameters.
- Is there a certain alpha at which X dies out and Y dominates? Vice versa?
- Animated a contour plot of ratio of the birth rates of the two populations vs rate of transformation over time.
- Derived a differential equation to describe the growth of each population
- Solved DEs in Mathematica to confirm that JJ and my calculations were correct
- Modeled population in Mathematica using said DEs, generated another animation of birth rate ratio vs rate of transformation and compared to my simulation result.
- Consistent!

Current work

- Contour plot I generated of birth rate ratio vs rate of transformation is somewhat hard to read.
- Reduce variables and plot a number of line plots to make information more easily readable.
- Want to plot things like:
  - % of susceptible population vs ratio of birth rates at a given time
  - Susceptible population vs transformation rate at a given time
  - Susceptible population vs time for given birth rates and transformation rate
- Already have seen that within reasonable parameter ranges, variance in transformation rate has a much bigger impact on population growth than birth rate.

Next steps

- Right now we assume a fixed probability that a susceptible bacteria will acquire a plasmid and become resistant. We want to make this probability dependent on the size of the susceptible population – if there are more susceptible bacteria, it's more likely one will run into a plasmid.

- We will use a Hill function for this – related to the logistic function, can model the probability increasing as the population increases
- Calculate equilibrium conditions for the resistant population
- Susceptible population is only at equilibrium when the population is at 0, or at the environment's carrying capacity – if we start it off at some state in between, which equilibrium point will it tend to?
- Incorporate death rate (necessary for previous step)