Simulation and Theory of Bacterial Transformation

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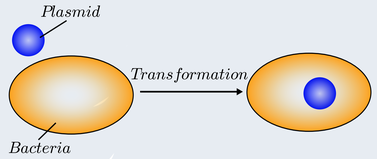
Introduction

- Ubiquitous threat of antibiotic resistant bacteria
- Investigate effect of different cellular transformation rates on antibiotic resistant bacterial population growth



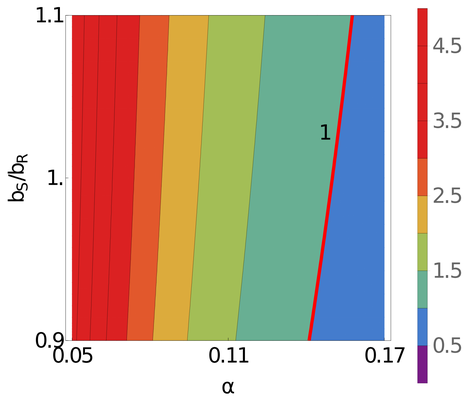
Biological Background

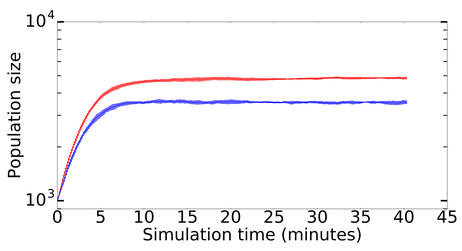
- Plasmids
- Fitness cost
- Transformation

Simulation Methods

- Combined approach of Kinetic Monte Carlo simulation and numerical modeling
- Gillespie algorithm
- Well-mixed population
- Carrying capacity
- Constant, Linear, Recycled α
- Symmetric division
- Realtime conversion

Constant α





Parameters

α	.13	$\frac{b_S}{b_R}$	1.07
S_0	1e3	R_0	1e3
P_0	1e4	K	1e4

- Susceptible
- Resistant

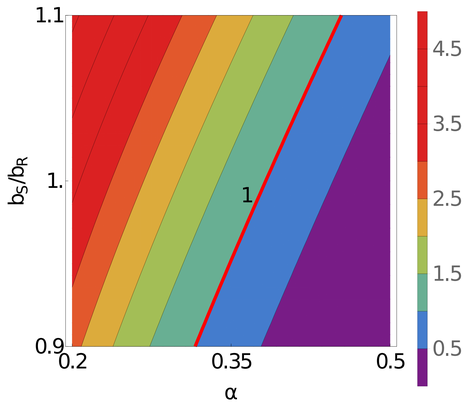
Reactions

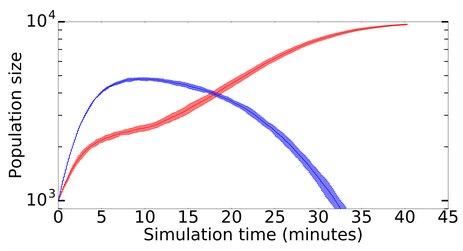
$$S \xrightarrow{b_S} 2S$$
$$S \xrightarrow{\alpha} R$$
$$R \xrightarrow{b_R} 2R$$
$$R \xrightarrow{\delta} \varnothing$$

Equations

$$\frac{dS}{dt} = b_S\left(1-\frac{S+R}{K}\right)S - \alpha S$$
$$\frac{dR}{dt} = b_R\left(1-\frac{S+R}{K}\right)R + \alpha S - \delta R$$

Linear α





Parameters

α	.3	$\frac{b_S}{b_R}$	1.07
S_0	1e3	R_0	1e3
P_0	1e4	K	1e4

- Susceptible
- Resistant

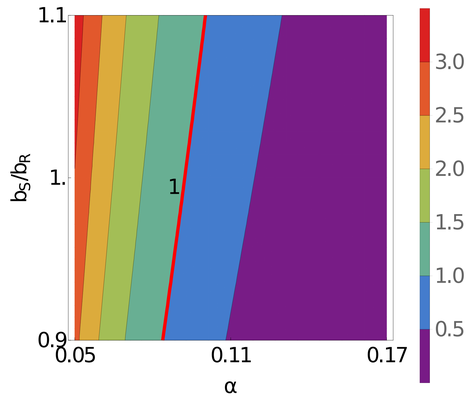
Reactions

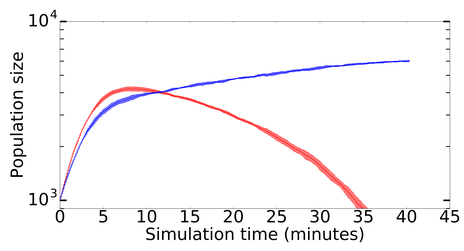
$$S \xrightarrow{b_S} 2S$$
$$S + P \xrightarrow{\alpha} R$$
$$R \xrightarrow{b_R} 2R$$
$$R \xrightarrow{\delta} \varnothing$$

Equations

$$\frac{dS}{dt} = b_S\left(1-\frac{S+R}{K}\right)S - \alpha\left(\frac{P}{P_0}\right)S$$
$$\frac{dR}{dt} = b_R\left(1-\frac{S+R}{K}\right)R + \alpha\left(\frac{P}{P_0}\right)S - \delta R$$
$$\frac{dP}{dt} = -\alpha\left(\frac{P}{P_0}\right)S$$

Recycled α





Parameters

α	.13	$\frac{b_S}{b_R}$	1.07
S_0	1e3	R_0	1e3
P_0	1e4	K	1e4

- Susceptible
- Resistant

Reactions

$$S \xrightarrow{b_S} 2S$$
$$S + P \xrightarrow{\alpha} R$$
$$R \xrightarrow{b_R} 2R$$
$$R \xrightarrow{\delta} \varnothing + P$$

Equations

$$\frac{dS}{dt} = b_S\left(1-\frac{S+R}{K}\right)S - \alpha\left(\frac{P}{P_0}\right)S + +b_R\left(1-\frac{S+R}{K}\right)R$$
$$\frac{dR}{dt} = \alpha\left(\frac{P}{P_0}\right)S - \delta R$$
$$\frac{dP}{dt} = -\alpha\left(\frac{P}{P_0}\right)S + \delta R$$

Conclusions

- S/R transition point depends on both rate and mechanism
- Population extinction in linear case

Future Work

- Simulation on a lattice
- Adding antibiotics
- Asymmetric division

Acknowledgements/References

Thank you etc etc

- Source 1
- Source 2