Modelling Fitness Trade-Offs of Rates of Horizontal Gene Transfer

Evolution 02-731 Project

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May 6 2021

Background

Horizontal Gene Transfer (HGT)

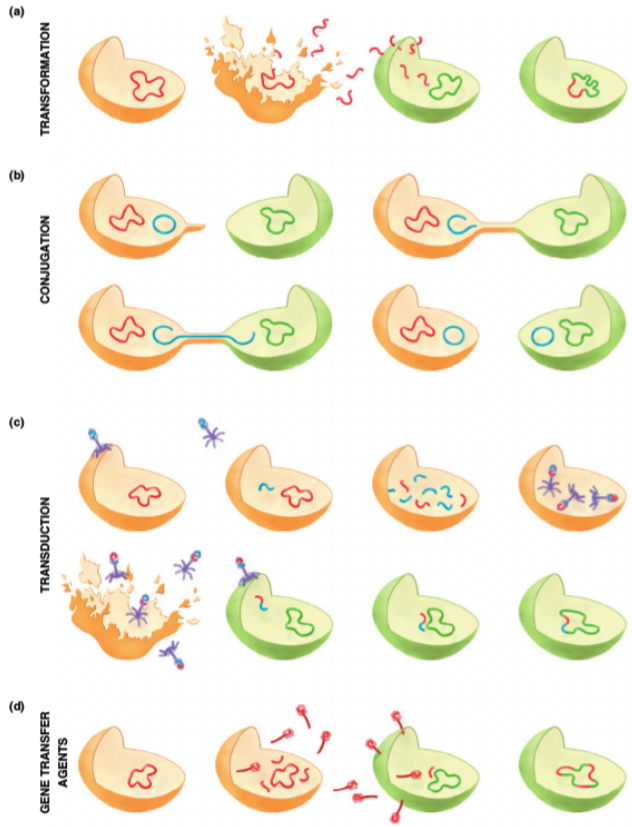

Figure 1: HGT Mechanisms

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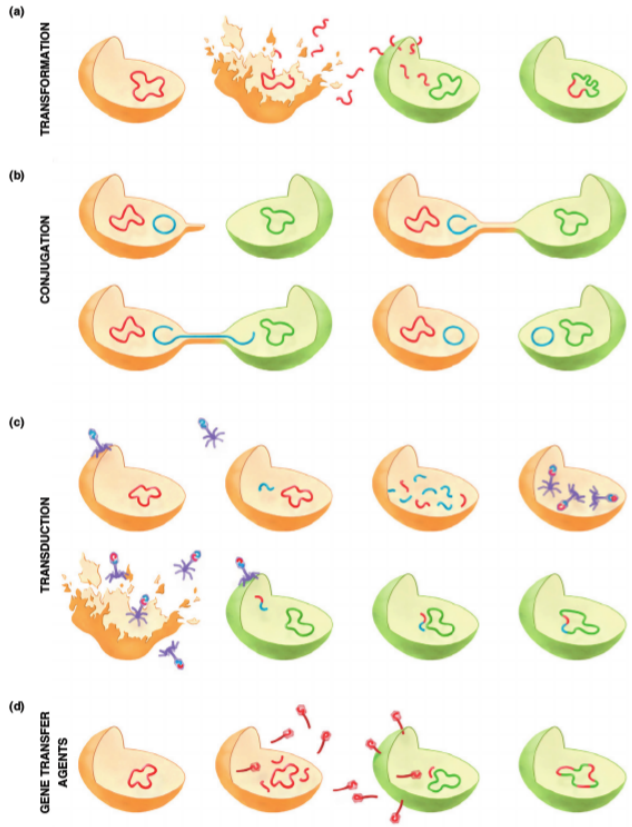

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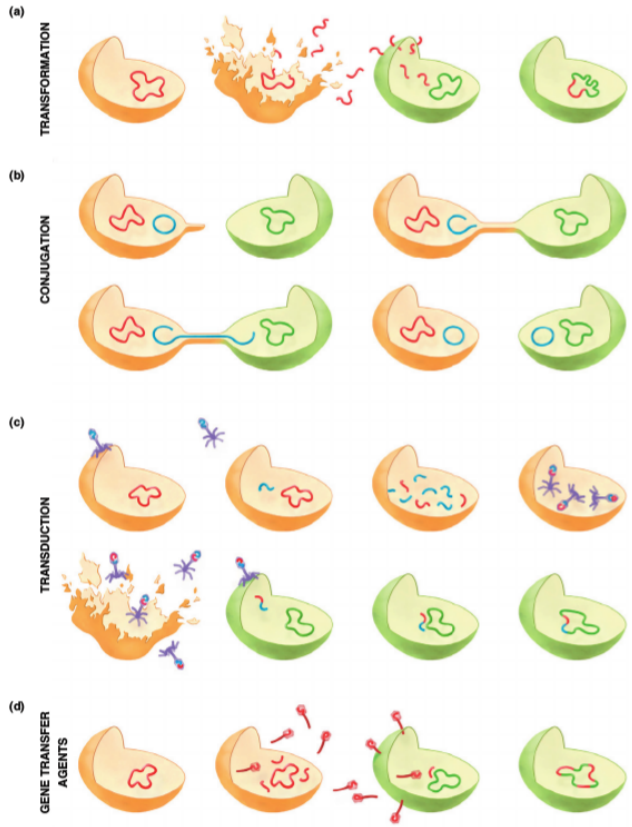

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- **Transduction:** Transfer of DNA via phage

CRISPR-Cas In Bacteria

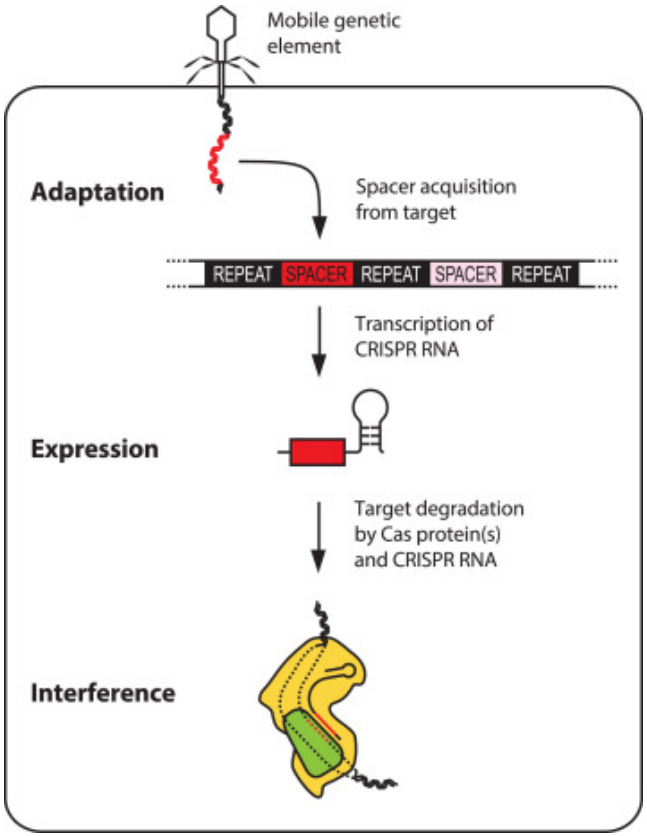

Figure 2: CRISPR-Cas Mechanism

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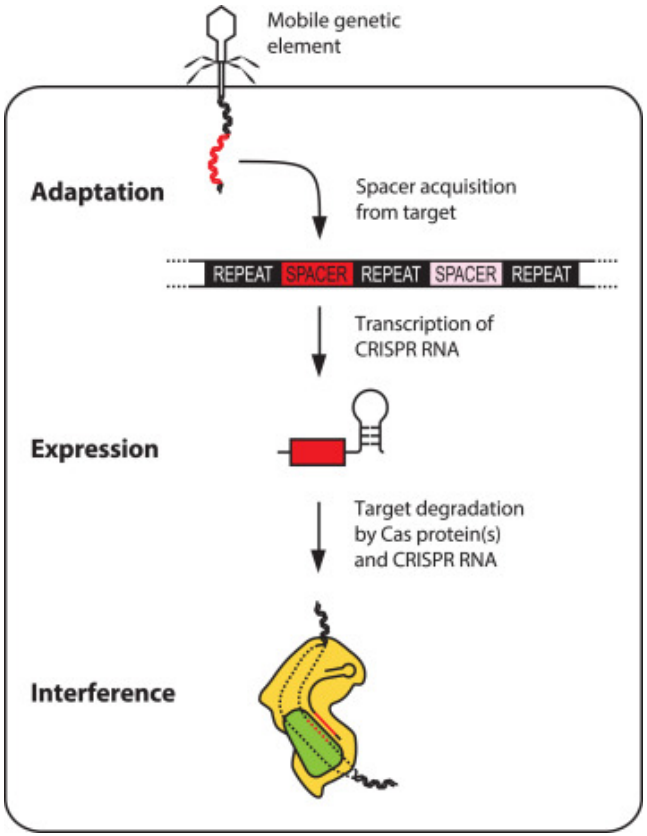

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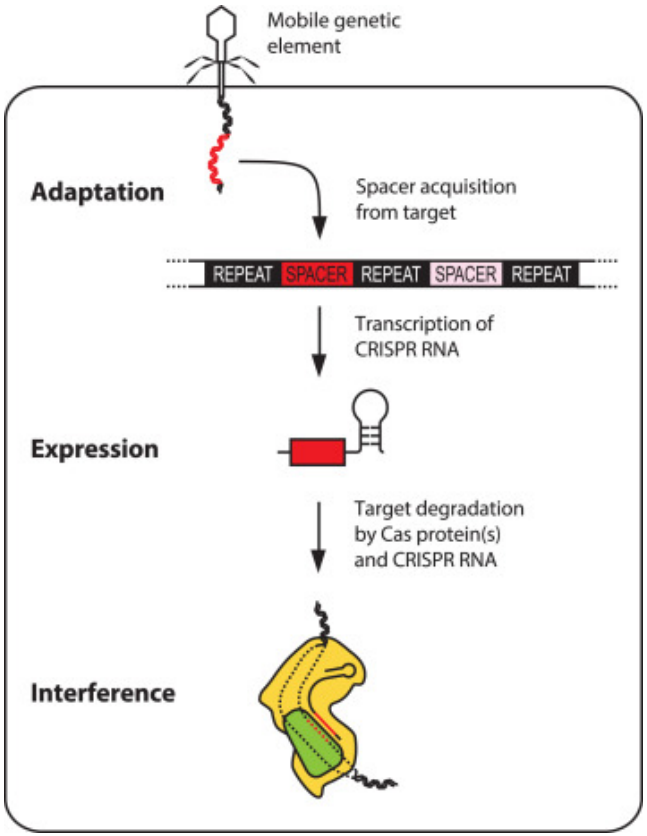

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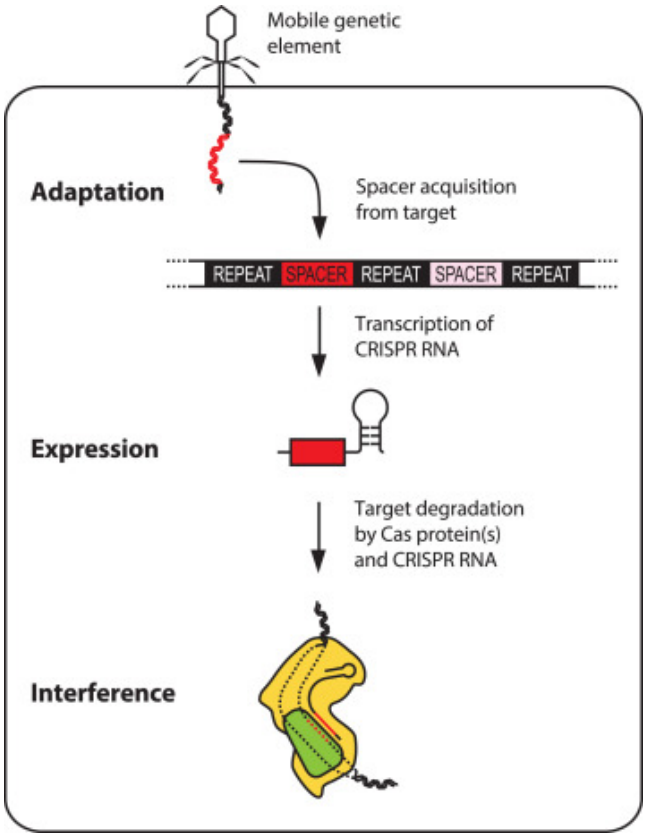

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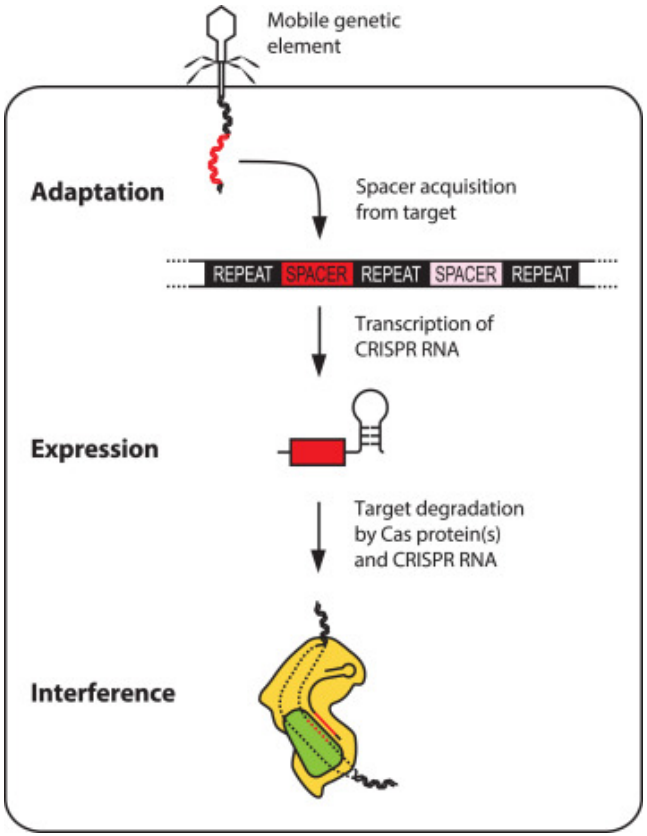

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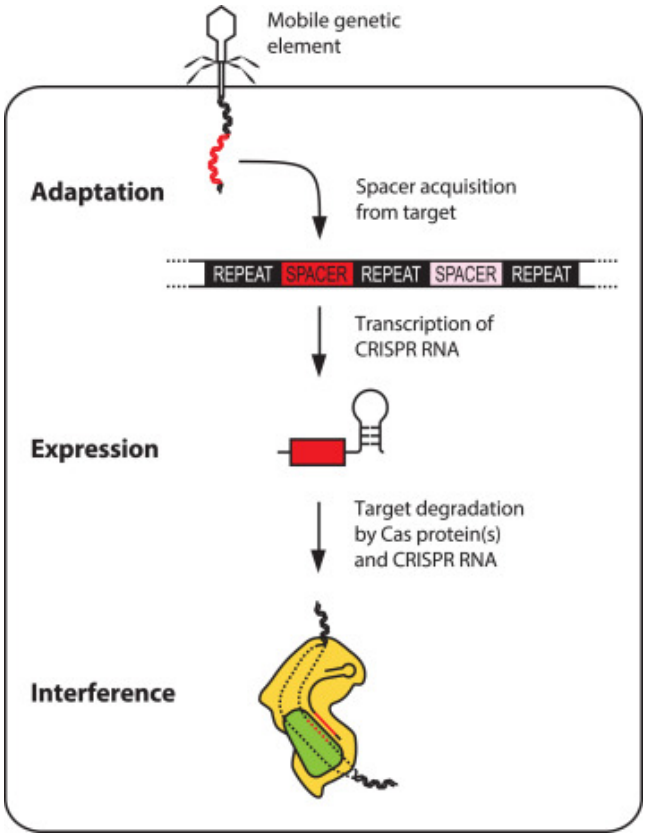

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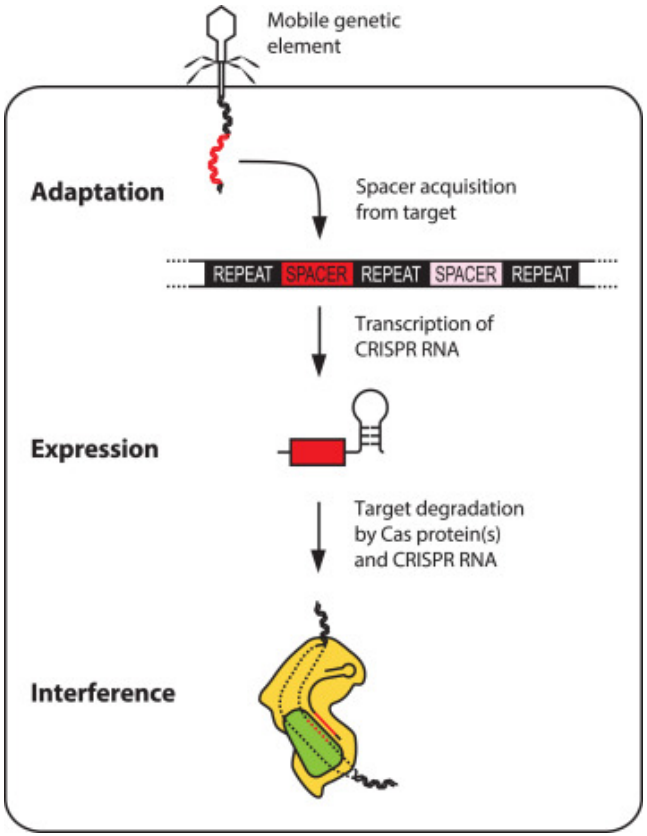

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- Protects against "foreign" DNA, but can acquire **any** DNA as a spacer

Fitness Trade-offs

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- metabolic cost to maintain CRISPR or HGT machinery expression
- CRISPR systems can also be transferred between bacteria via plasmids

Model

Genotypes

Allele		Description
Major	Minor	
R	r	has/does not have resistance gene
H	h	HGT machinery is expressed/not expressed
C	c	CRISPR-Cas is expressed/not expressed

Table 1: Allele definitions

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  - mutation is $r \rightarrow R$ or $R \rightarrow r$

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- **Alternating Threat:** Same as Cyclical Threat model but switching between threats threats each event.

Fitness

Genotype	*Environment*		
	E_n	E_b	E_a
RCH	$1 - 2s_m$	$(1 + s_p)(1 - 2s_m)$	$(1 + s_p)(1 - 2s_m)$
RCh	$1 - s_m$	$(1 + s_p)(1 - s_m)$	$(1 + s_p)(1 - s_m)$
RcH	$1 - s_m$	$1 - s_m$	$(1 + s_p)(1 - s_m)$
Rch	1	1	$1 + s_p$
rCH	$1 - 2s_m$	$(1 + s_p)(1 - 2s_m)$	$1 - 2s_m$
rCh	$1 - s_m$	$(1 + s_p)(1 - s_m)$	$1 - s_m$
rcH	$1 - s_m$	$1 - s_m$	$1 - s_m$
rch	1	1	1

Table 2: Relative fitness values for each genotype in each environment

- s_m reflects cost of maintaining HGT/CRISPR, $s_m << s_p$

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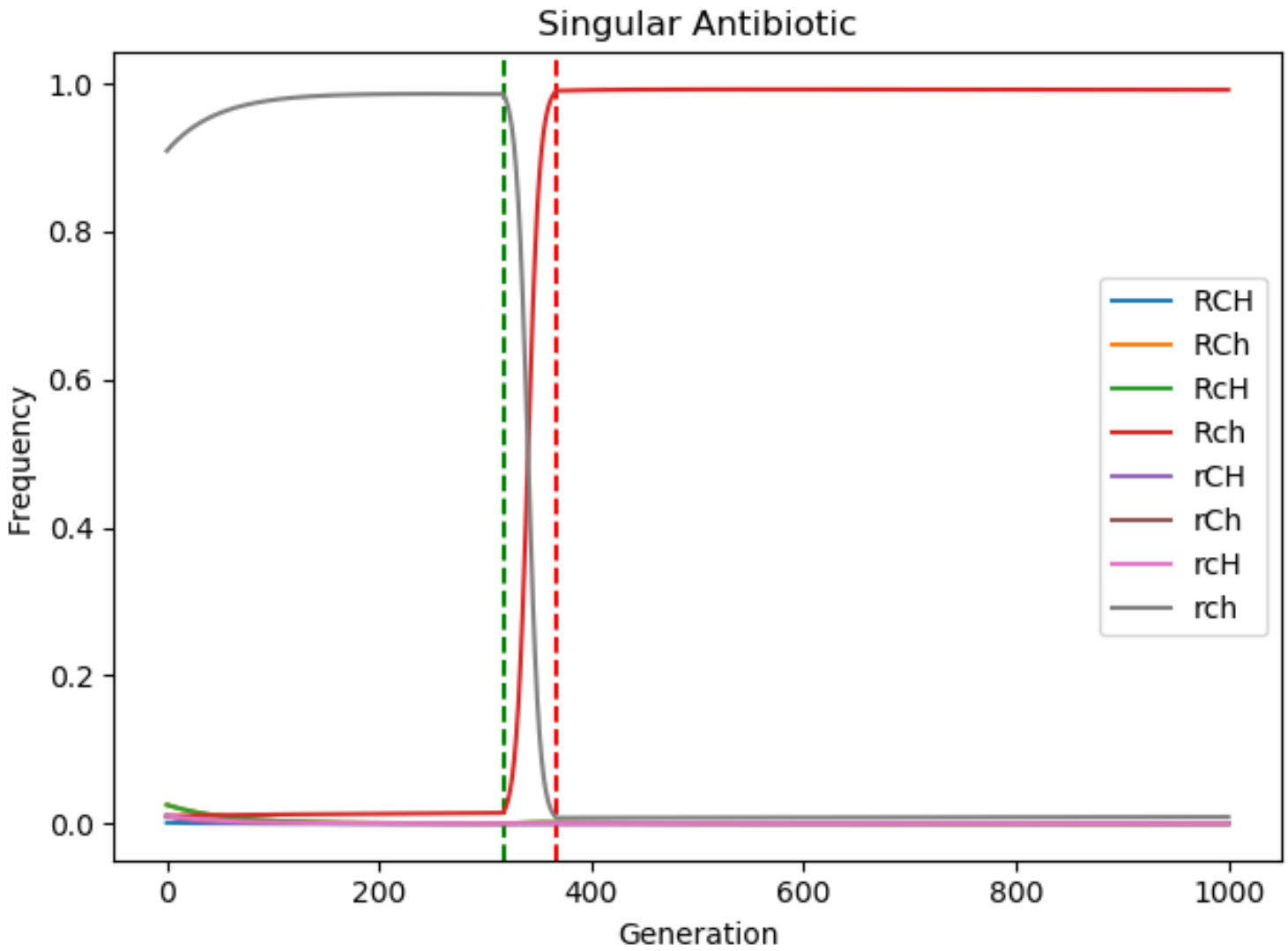
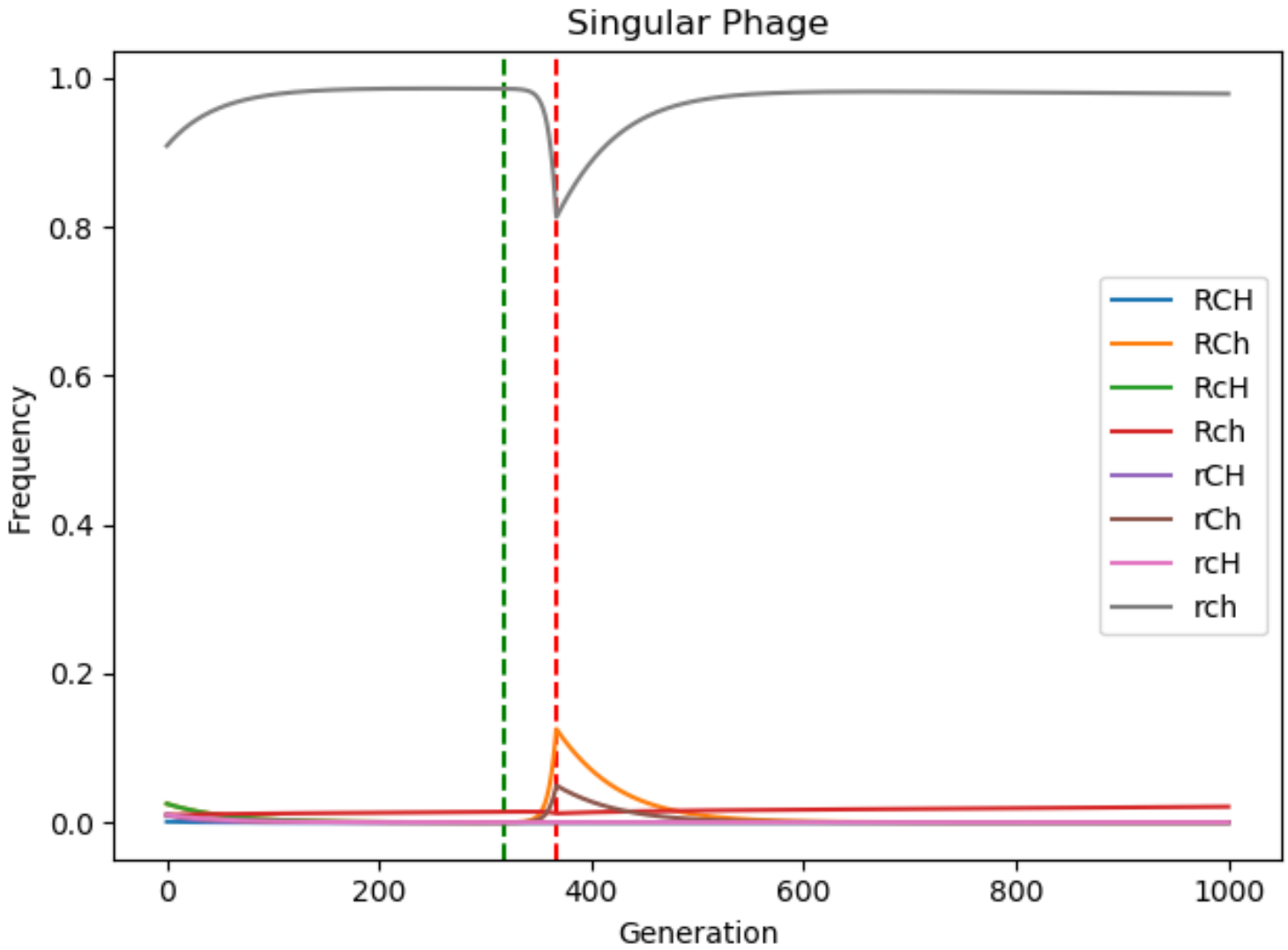
Results

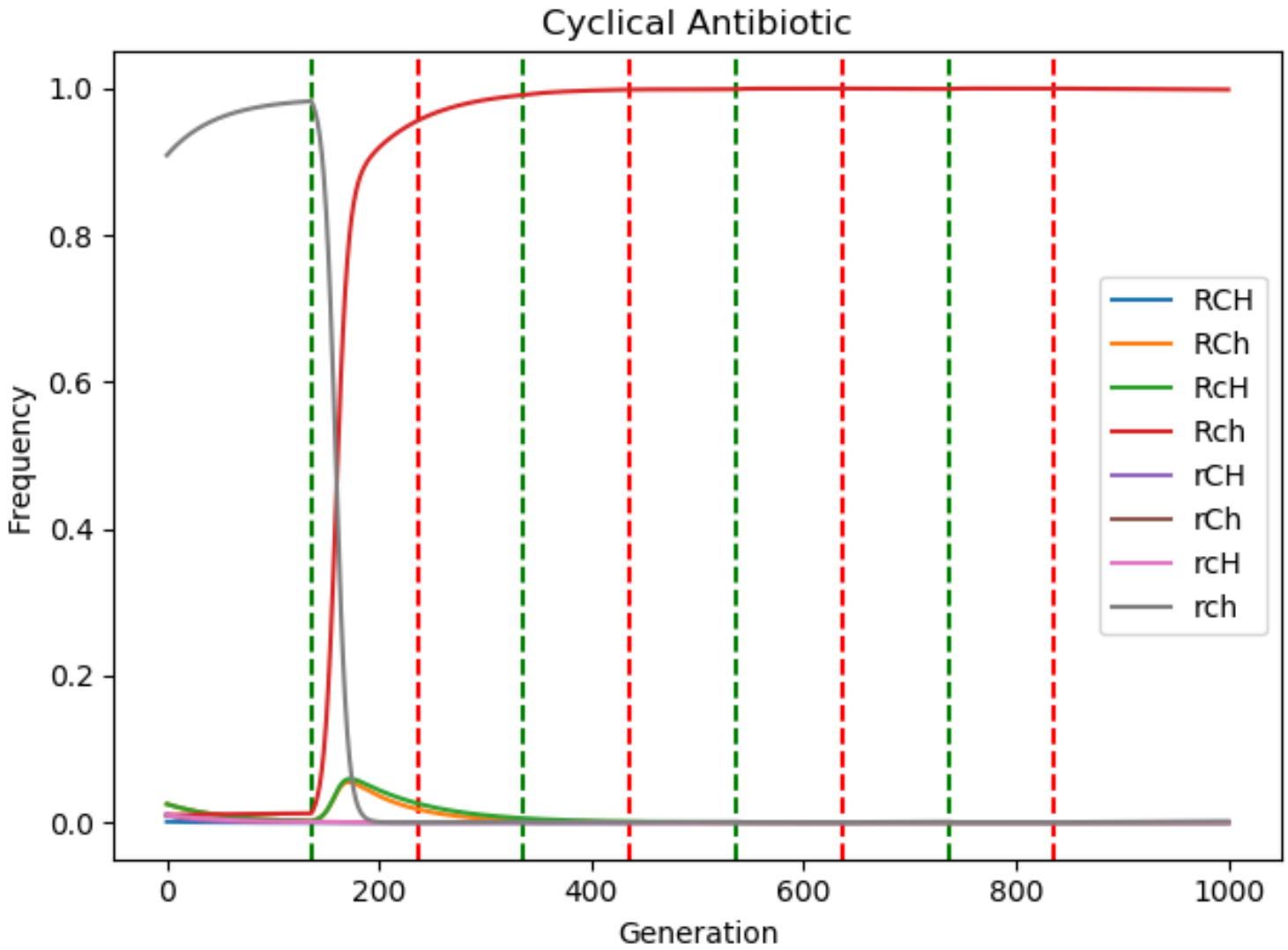
Single Antibiotic Event



Single Phage Event



Cyclical Antibiotic Events



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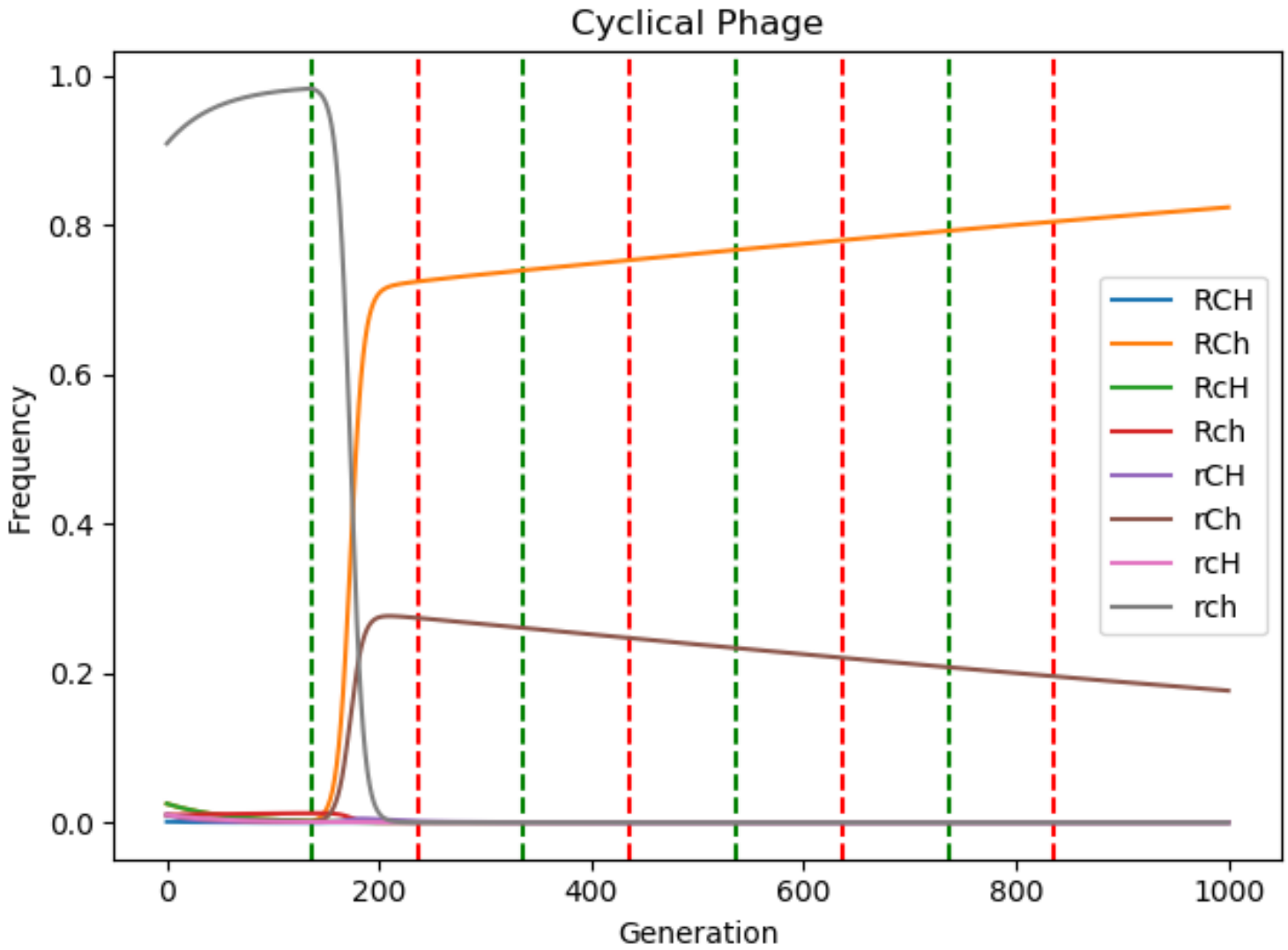
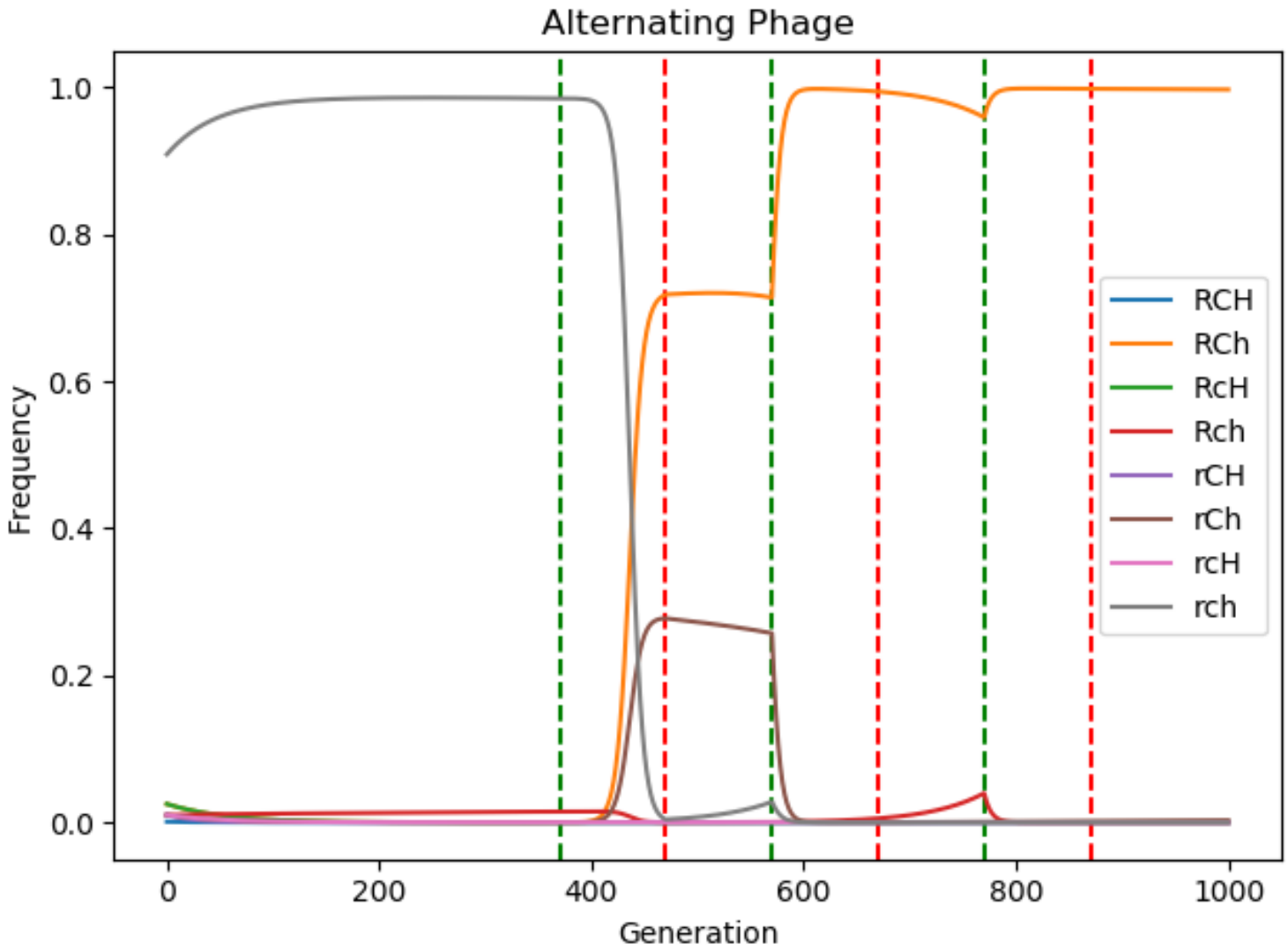
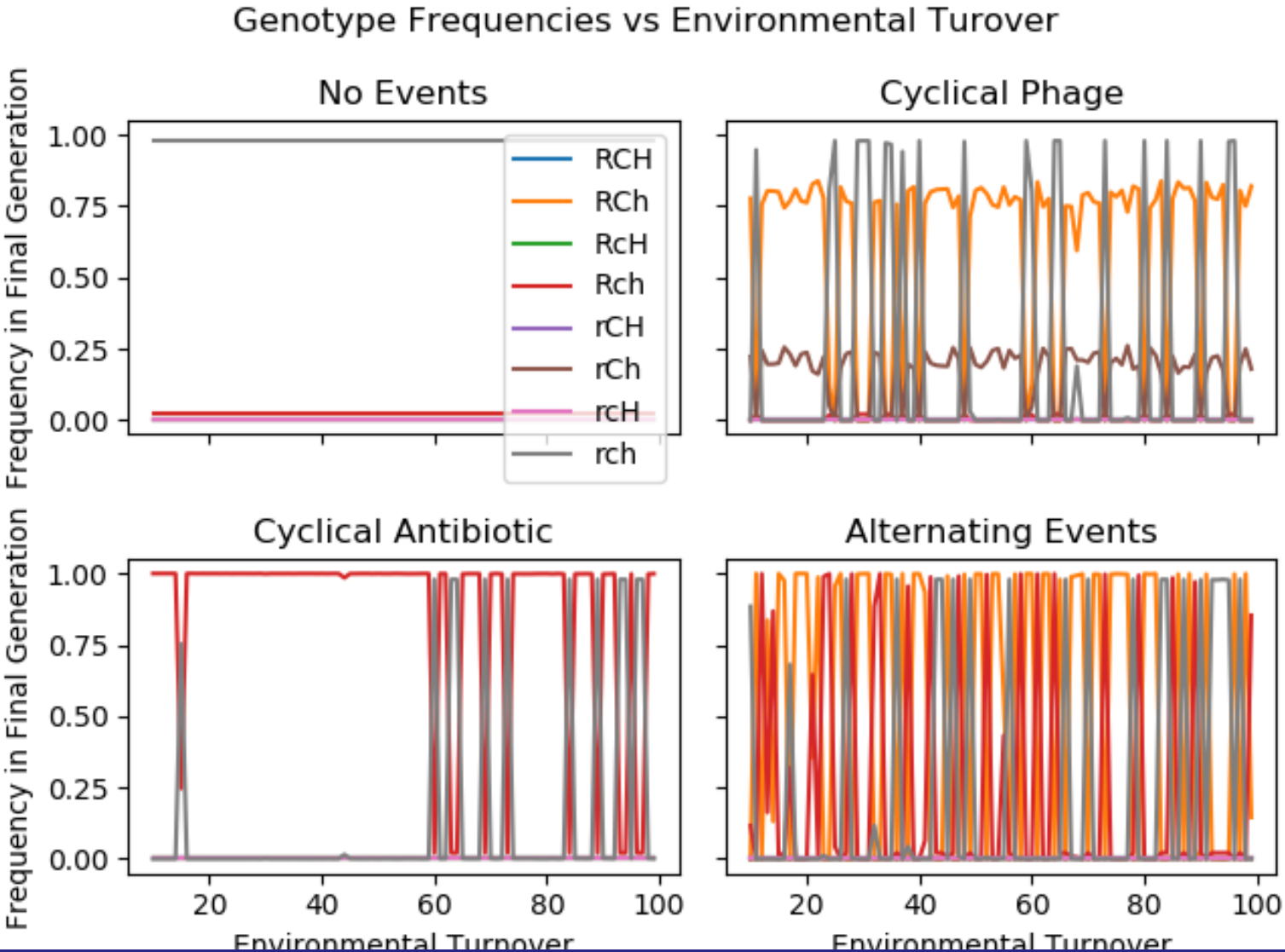


Alternating Events



Environmental Stability



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- incorporate terms that reflect biological trade-off of HGT/CRISPR