

Eco-evolutionary dynamics in asexual populations

Evolutionary rescue in Fisher's adaptive landscape

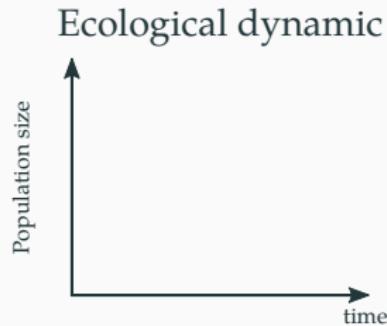
Yoann Anciaux

October 24, 2018

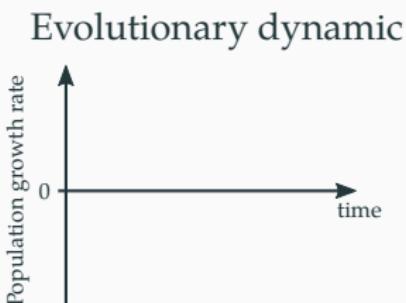
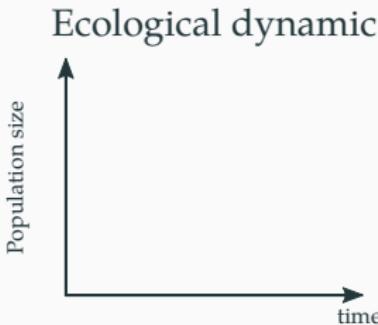
Bioinformatic research center Aarhus, Danemark.



Eco-evolutionary dynamics

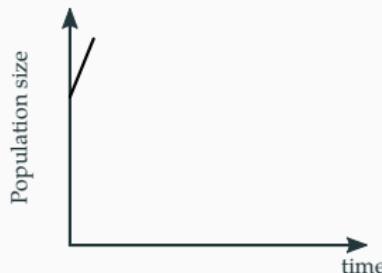


Eco-evolutionary dynamics

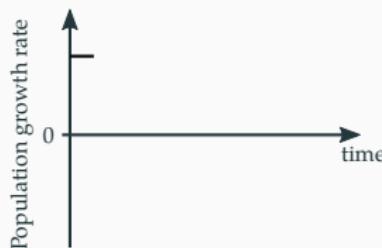


Eco-evolutionary dynamics

Ecological dynamic

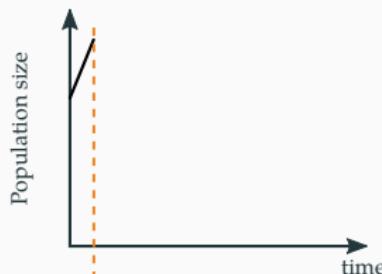


Evolutionary dynamic

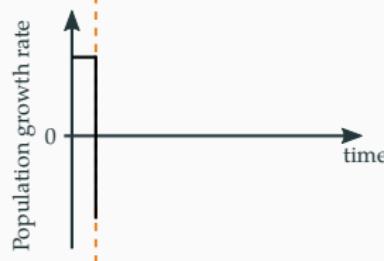


Eco-evolutionary dynamics

Ecological dynamic



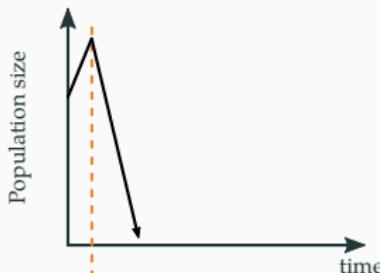
Evolutionary dynamic



Environmental
change

Eco-evolutionary dynamics

Ecological dynamic

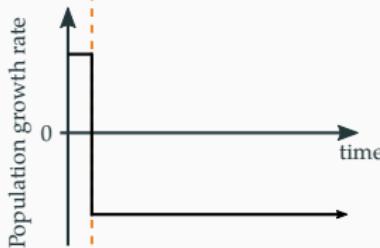


Outcomes



Extinction

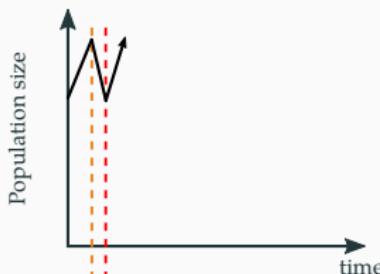
Evolutionary dynamic



Environmental
change

Eco-evolutionary dynamics

Ecological dynamic



Outcomes

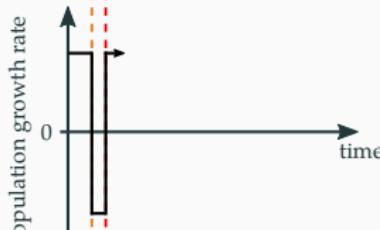


Extinction



Environmental
change

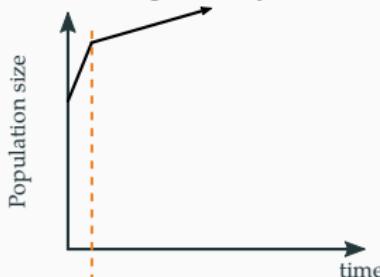
Evolutionary dynamic



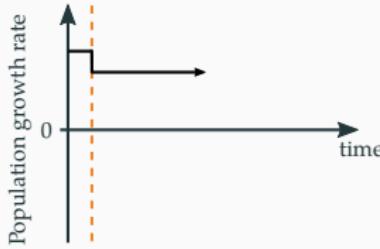
Environmental
change

Eco-evolutionary dynamics

Ecological dynamic



Evolutionary dynamic



Environmental change

Outcomes



Extinction



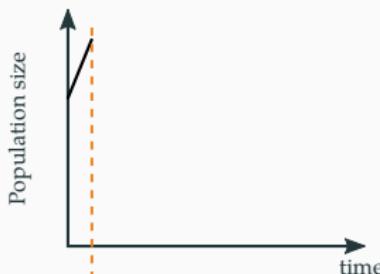
Environmental change

Phenotypic plasticity

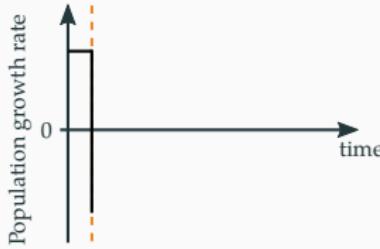


Eco-evolutionary dynamics

Ecological dynamic



Evolutionary dynamic



Environmental change

Outcomes



Extinction



Environmental change

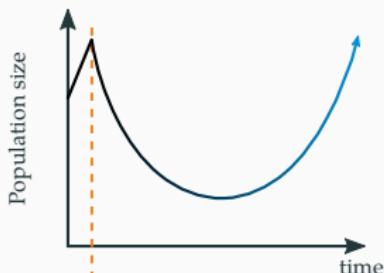
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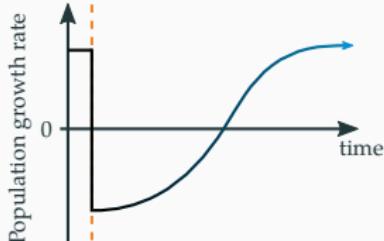
Genetic change

Eco-evolutionary dynamics

Ecological dynamic



Evolutionary dynamic



Environmental change

Outcomes



Extinction

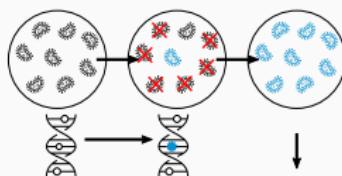


Environmental change

Phenotypic plasticity

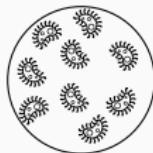


Genetic change



Evolutionary rescue

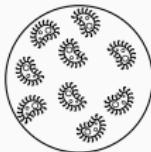
Genetic basis of evolutionary rescue



Genetic basis of
Evolutionary rescue

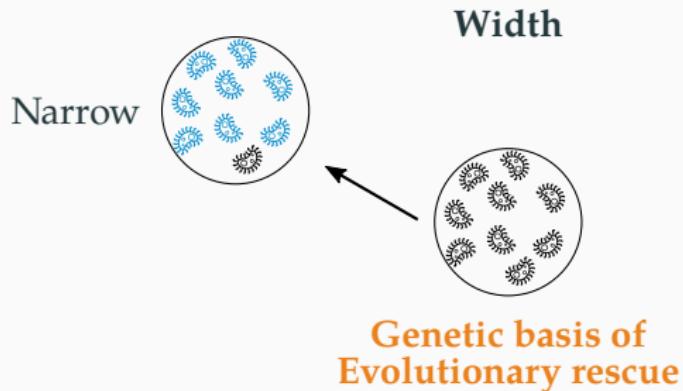
Genetic basis of evolutionary rescue

Width

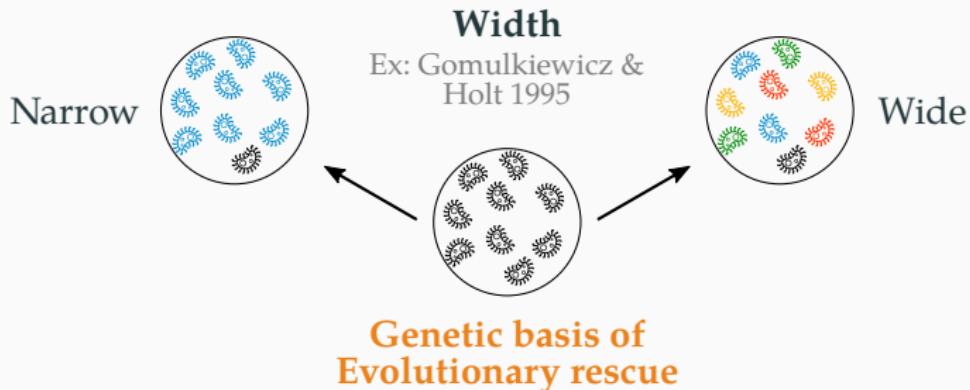


Genetic basis of
Evolutionary rescue

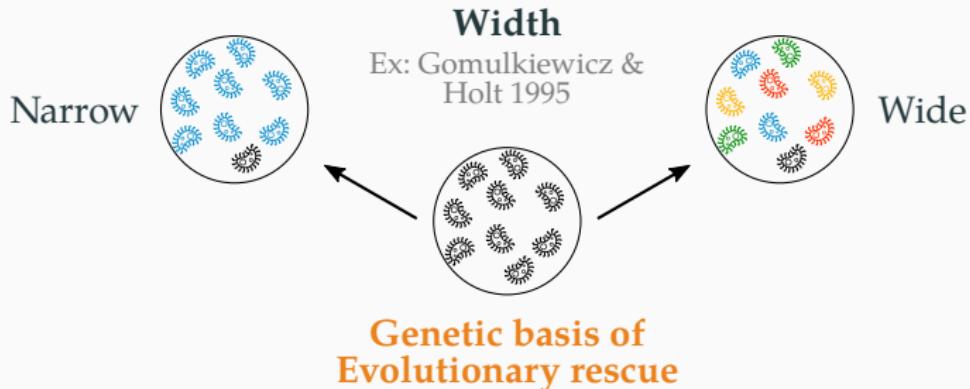
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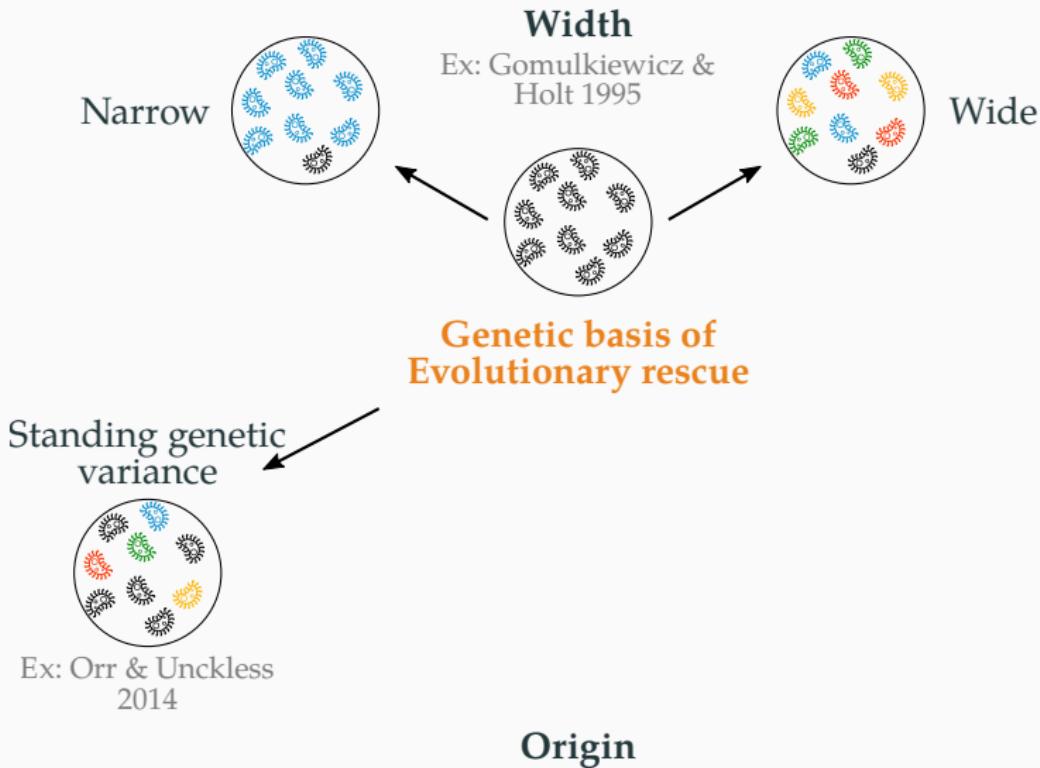


Genetic basis of evolutionary rescue

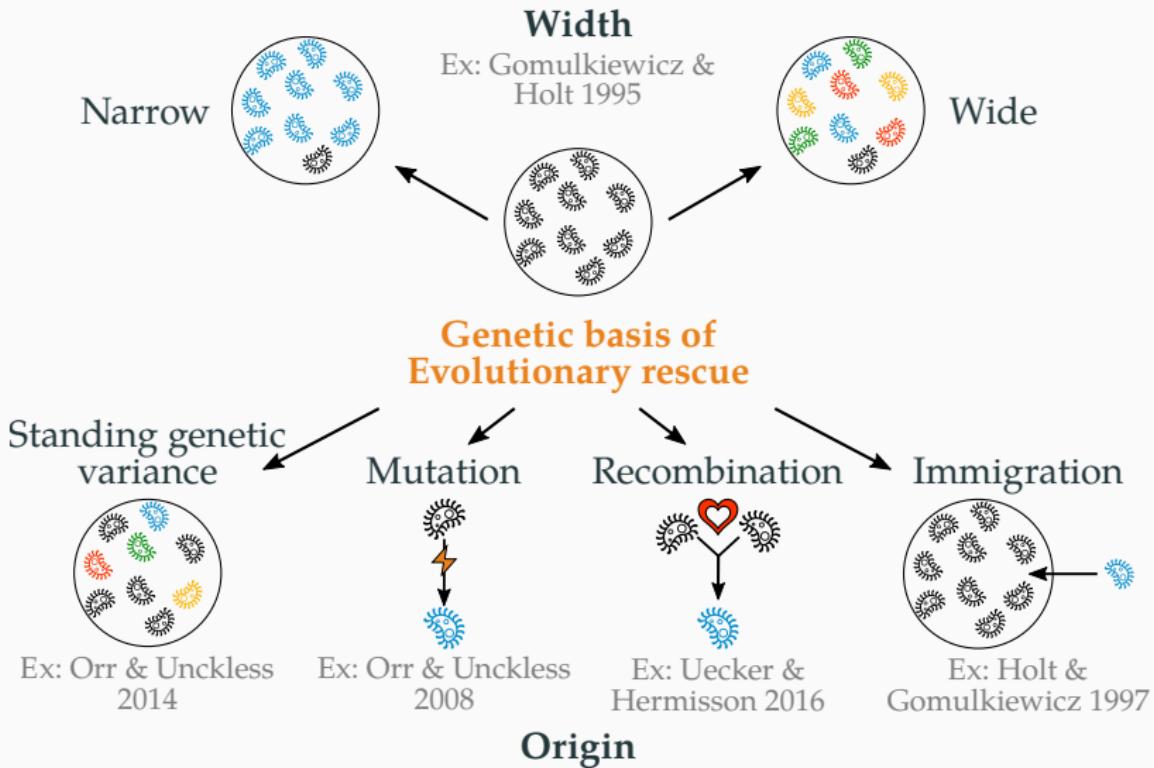


Origin

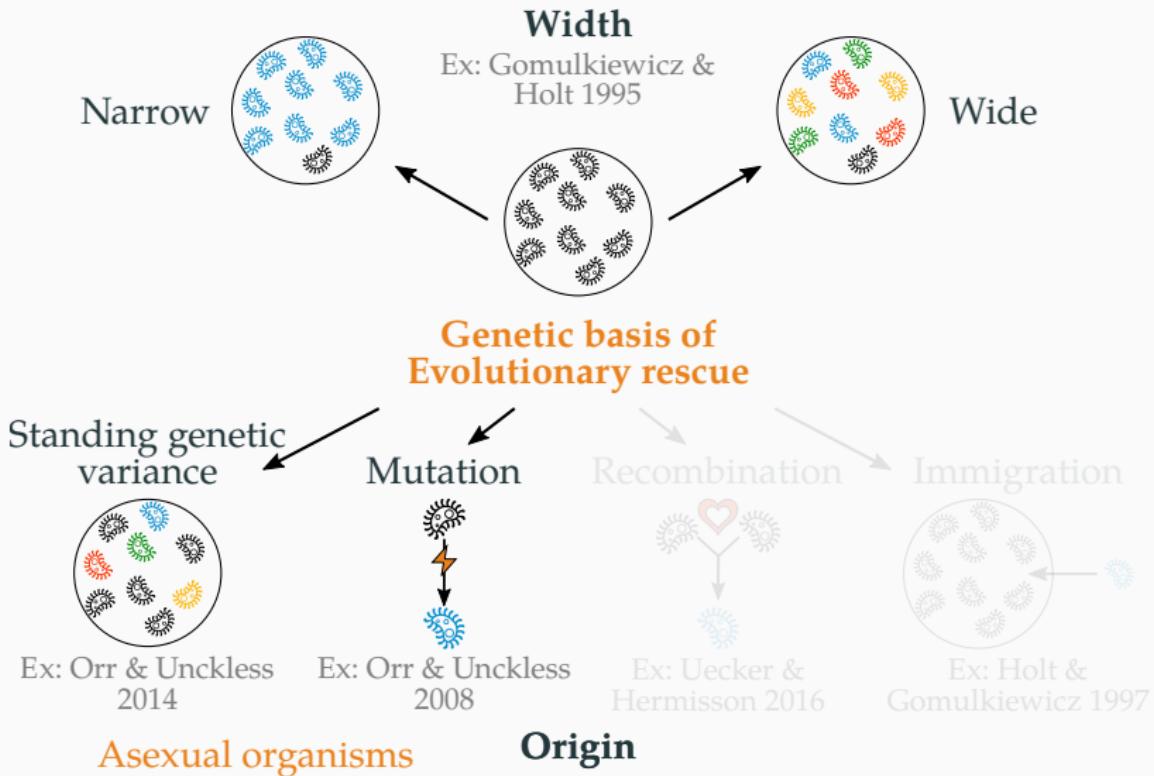
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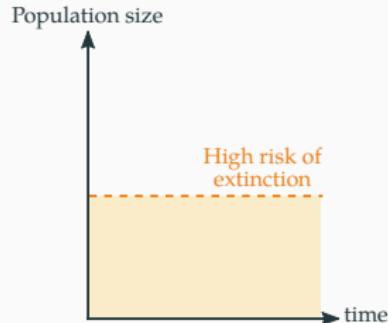
Genetic basis of evolutionary rescue



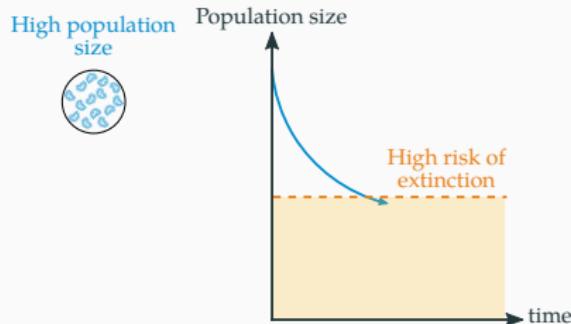
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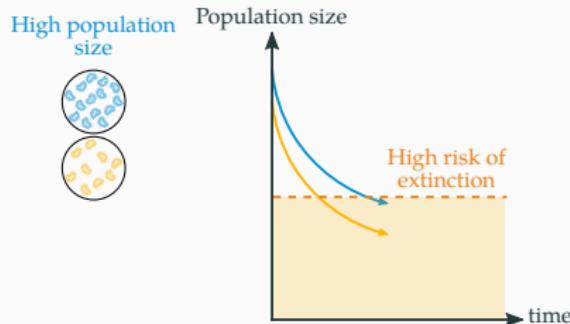
Model of evolutionary rescue from mutation



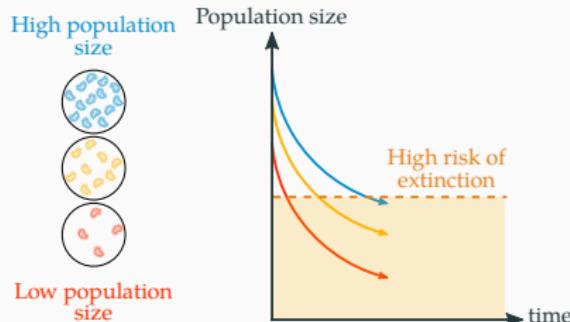
Model of evolutionary rescue from mutation



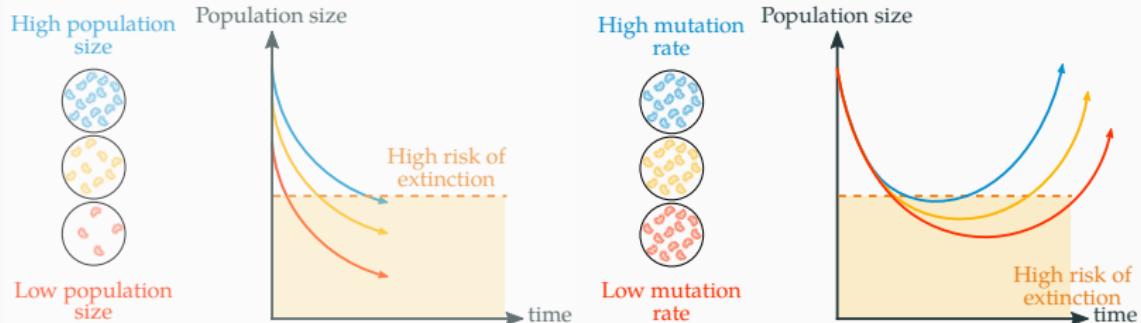
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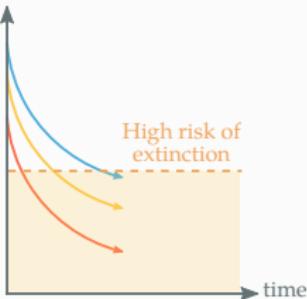
Model of evolutionary rescue from mutation

High population size



Low population size

Population size

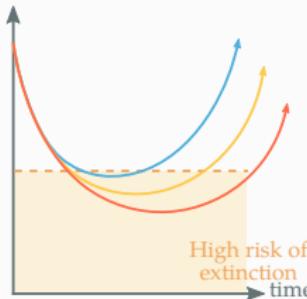


High mutation rate

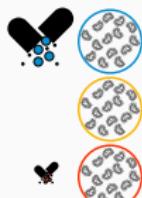


Low mutation rate

Population size

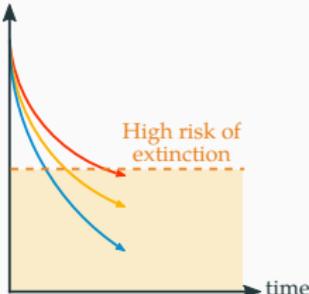


High environmental stress



Low environmental stress

Population size



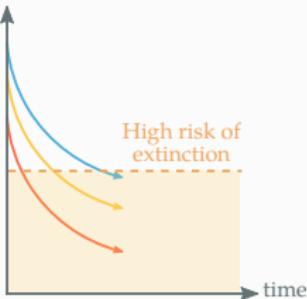
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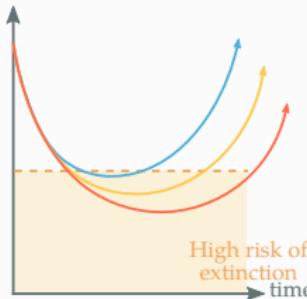


High mutation rate

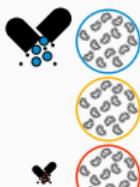


Low mutation rate

Population size

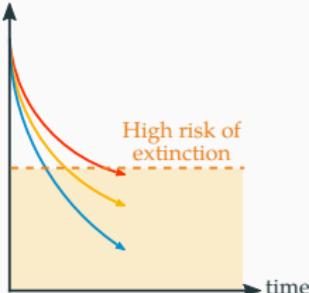


High environmental stress



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Population size



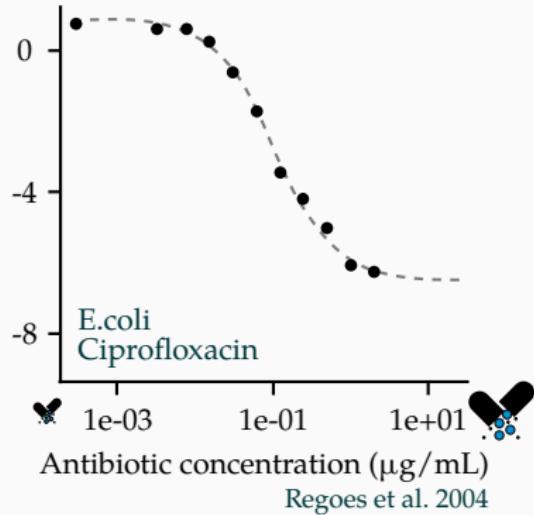
Effect of environmental change on demography

BUT

Fixed probability
of apparition of resistant mutations
across environments

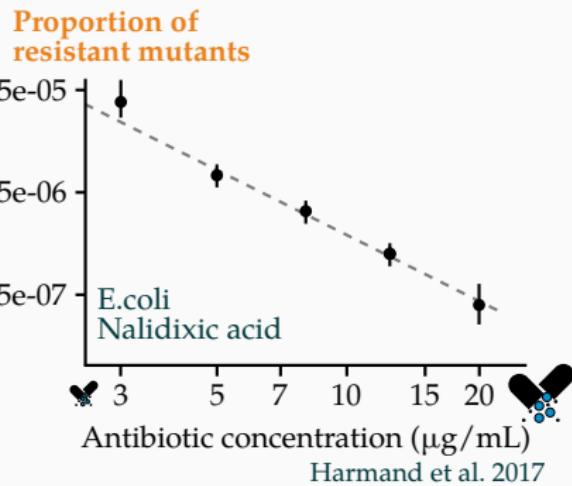
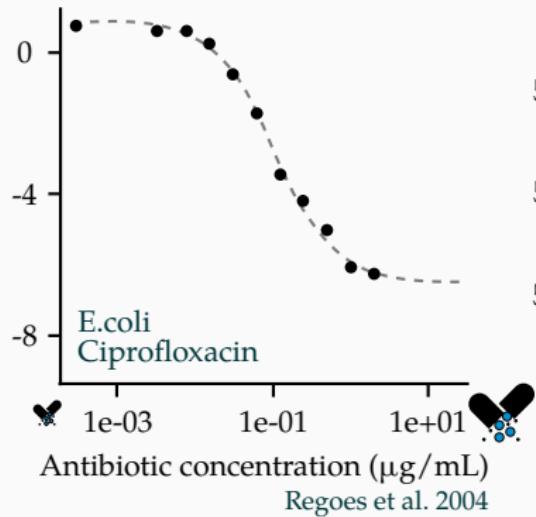
Model of evolutionary rescue from mutation

Maladaptation of the ancestor
= level of **environmental stress**



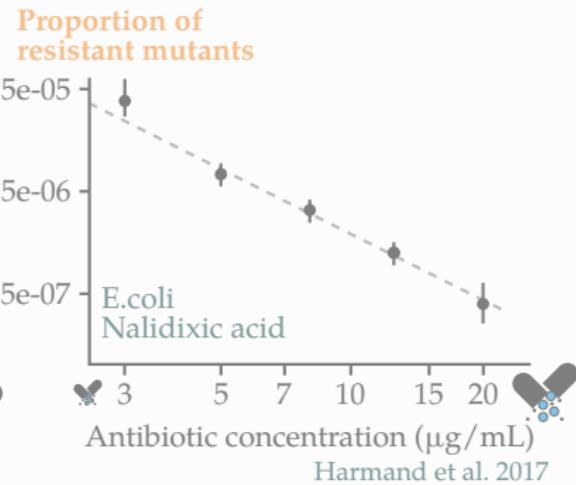
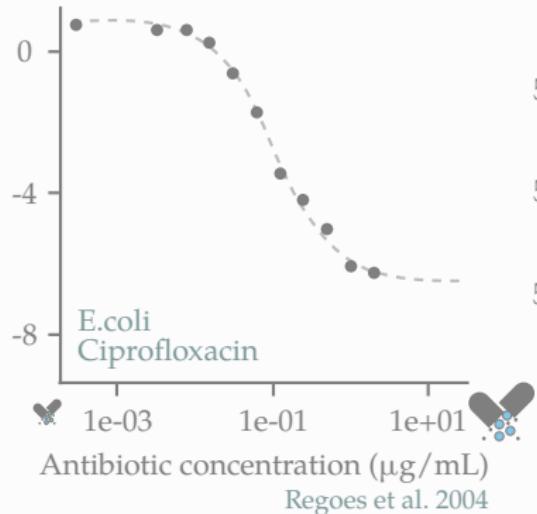
Model of evolutionary rescue from mutation

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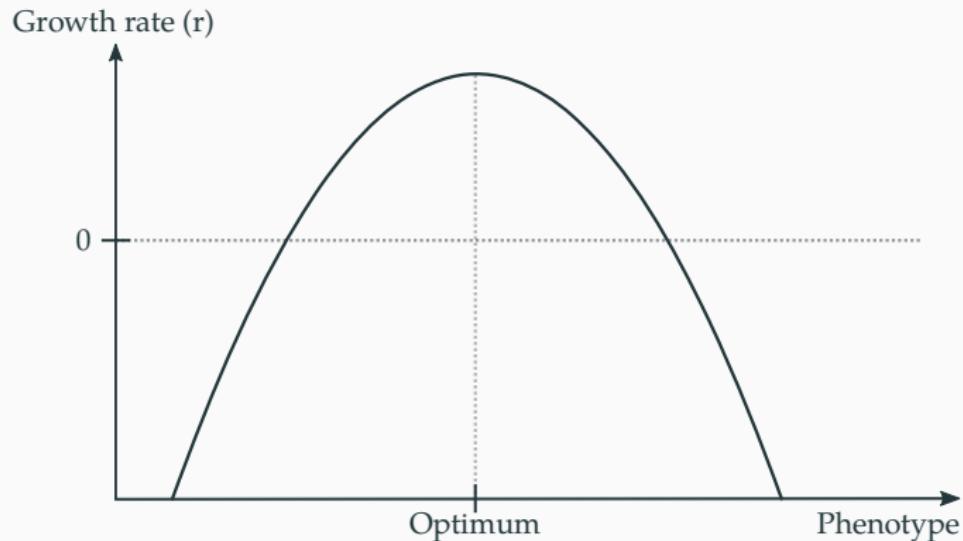
Model of evolutionary rescue from mutation

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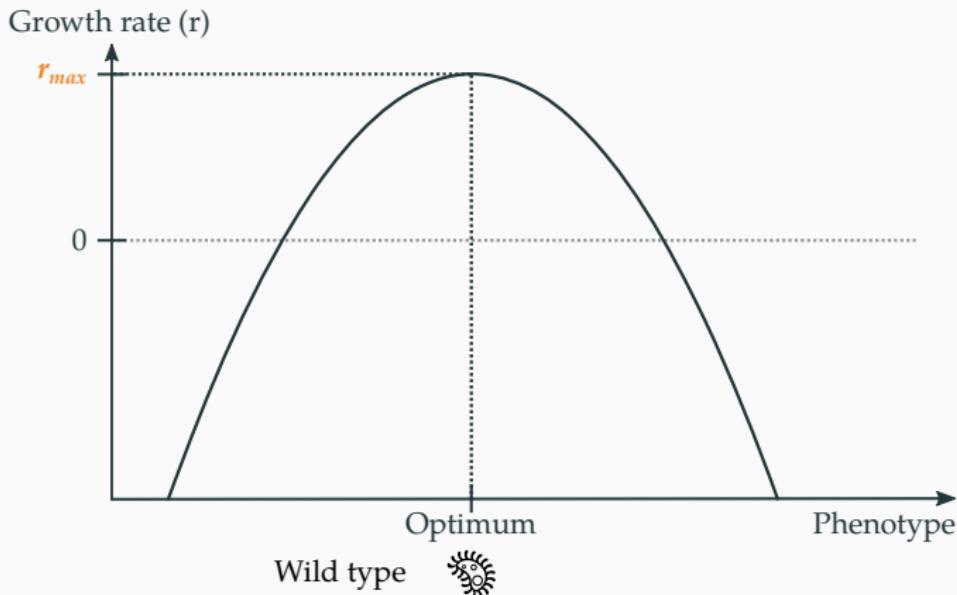
Derive ER models for asexual organisms integrating a **dependence between the environmental and the genetic contexts**

Fisher's Geometric Model



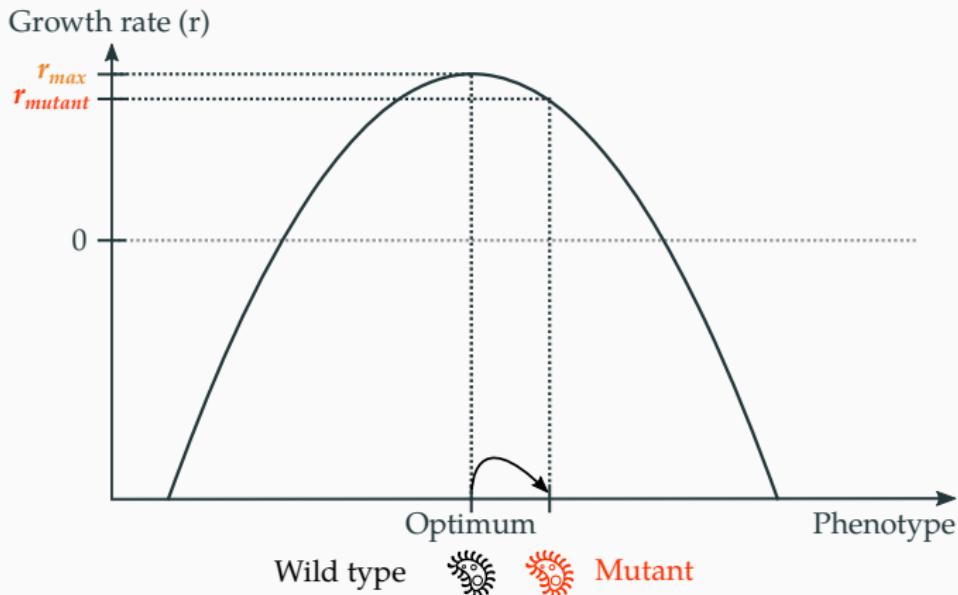
Fisher's Geometric Model

r_{max} : Maximal growth rate reachable in an environment.



Fisher's Geometric Model

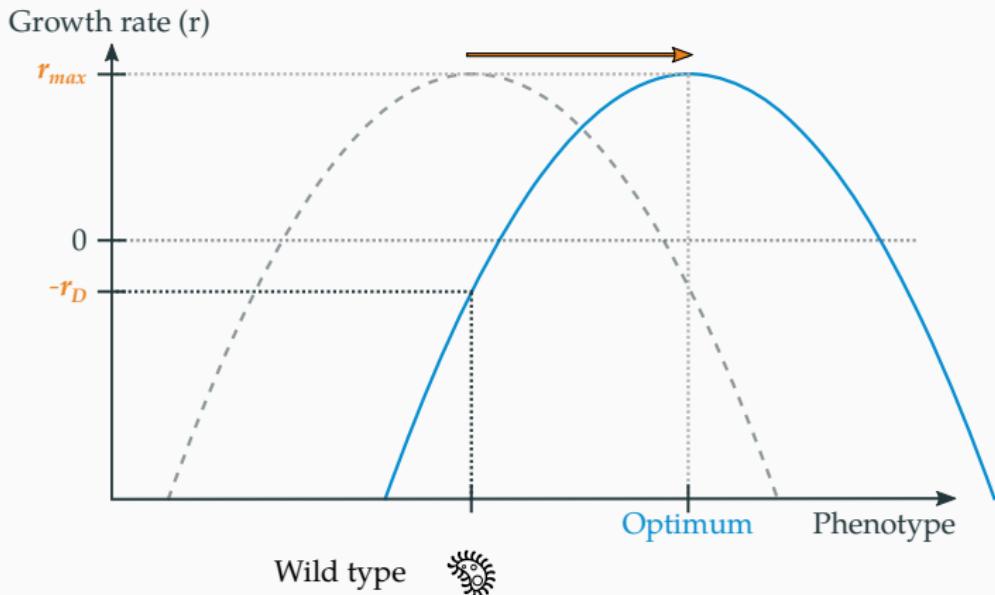
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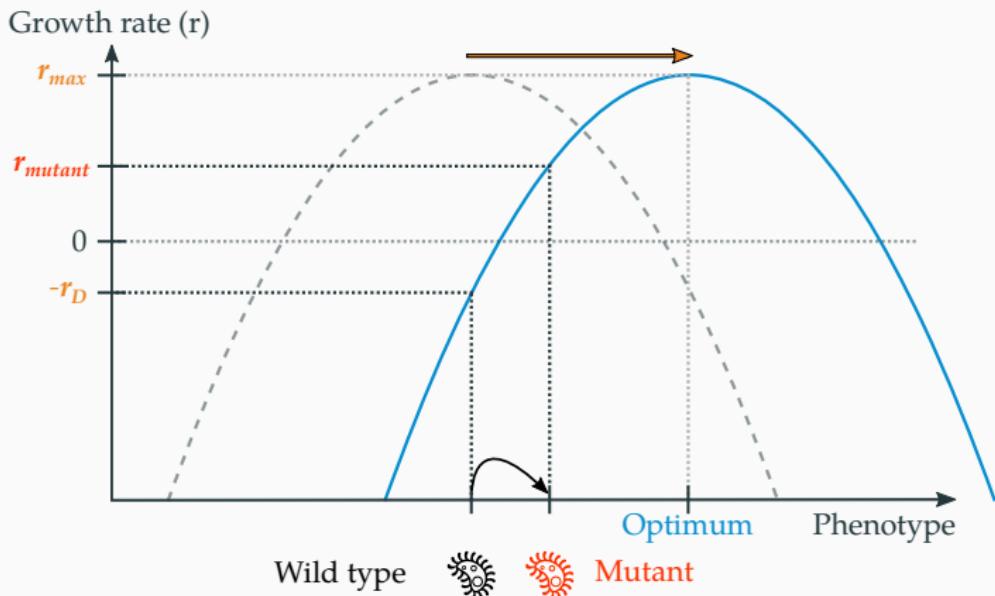
r_D : Decay rate of the wild type in the stressing environment.



Fisher's Geometric Model

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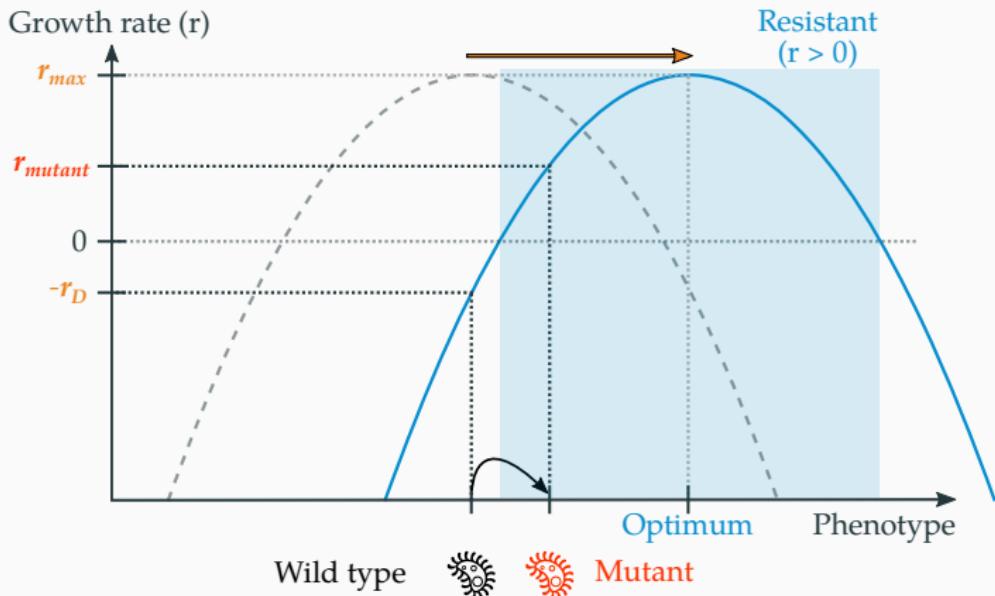
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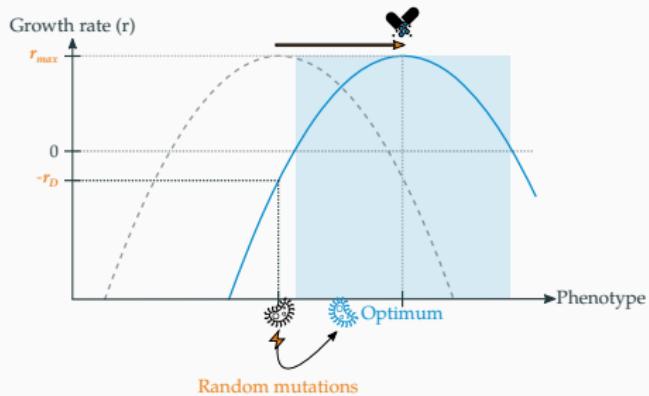
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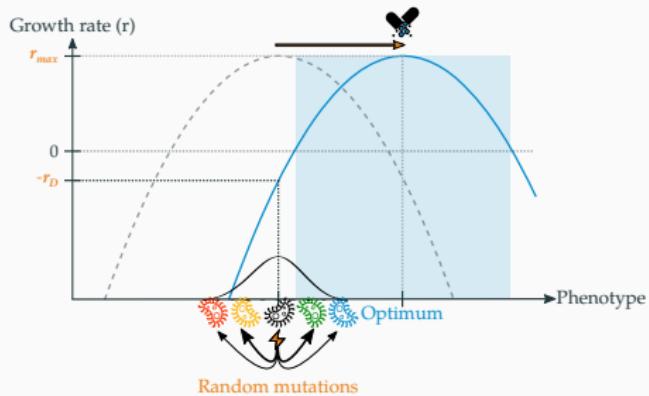
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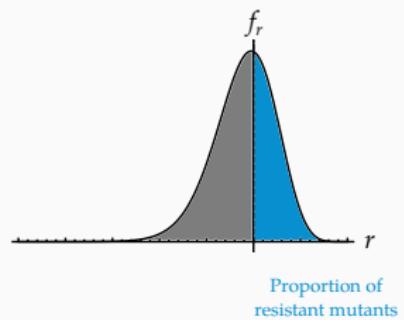
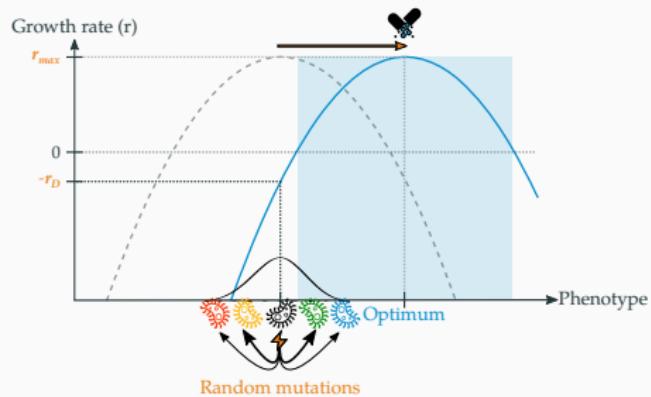
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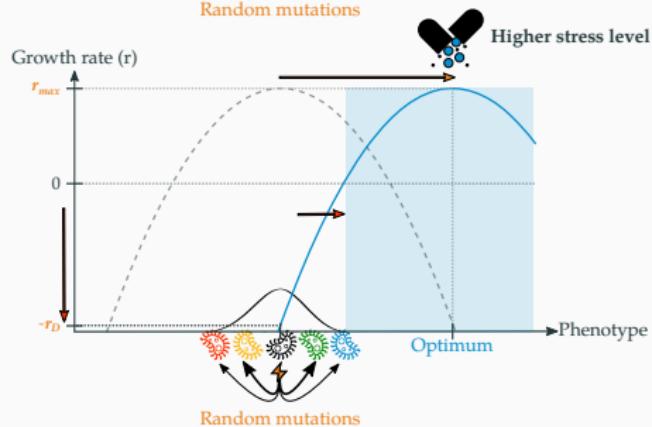
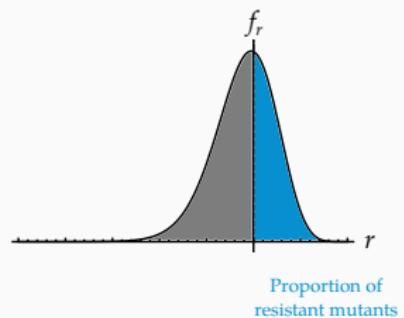
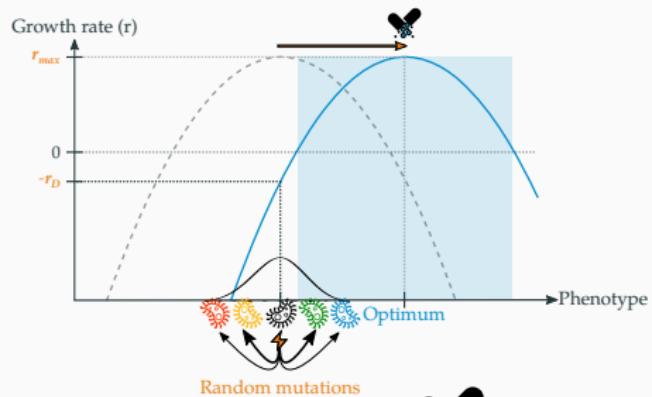
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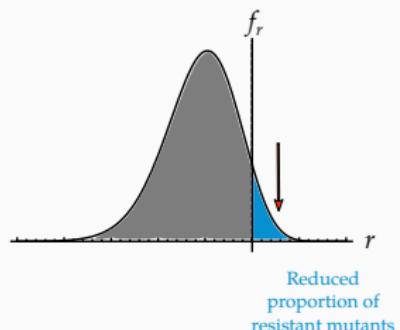
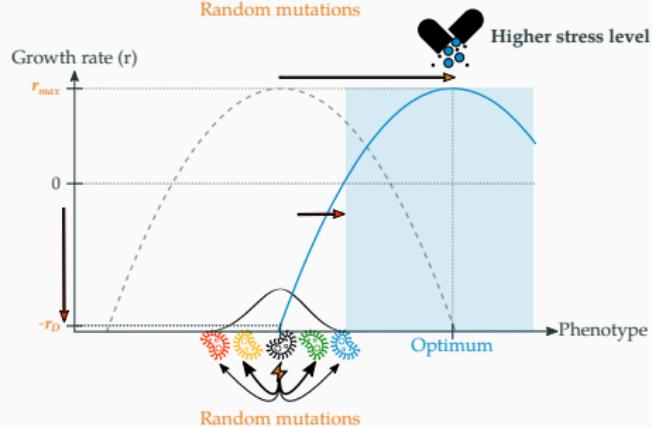
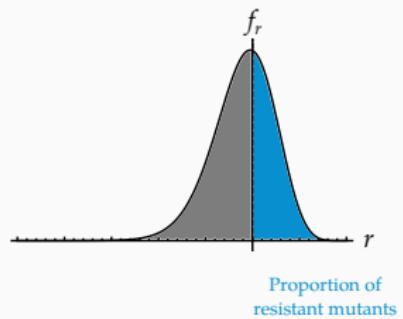
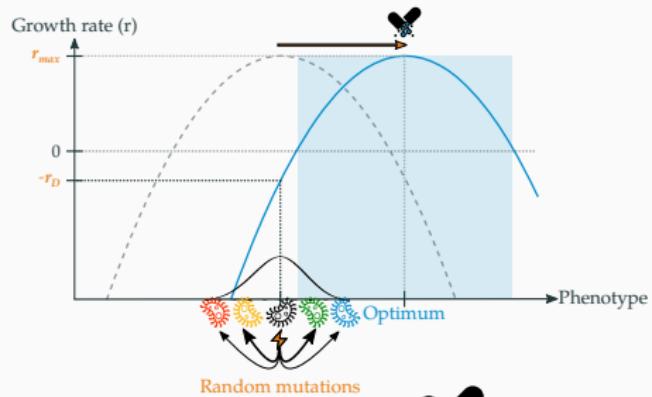
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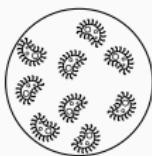
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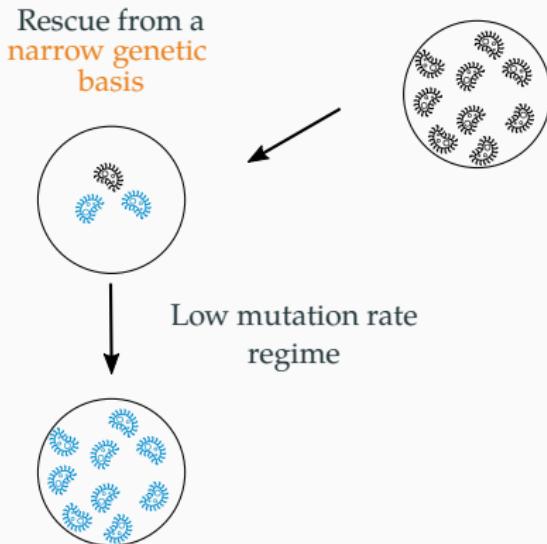
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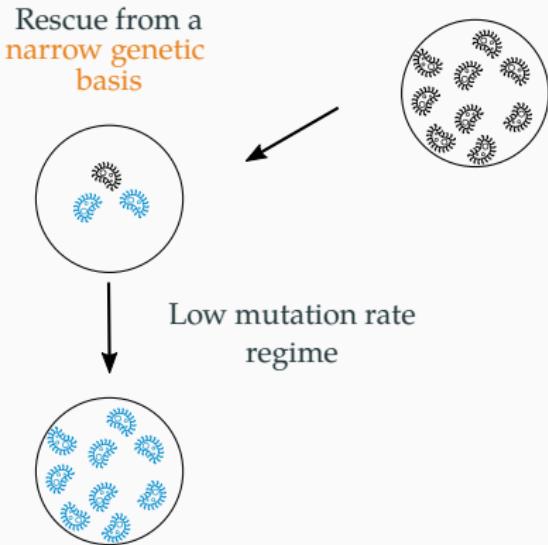
Two opposite mutation regimes



Two opposite mutation regimes

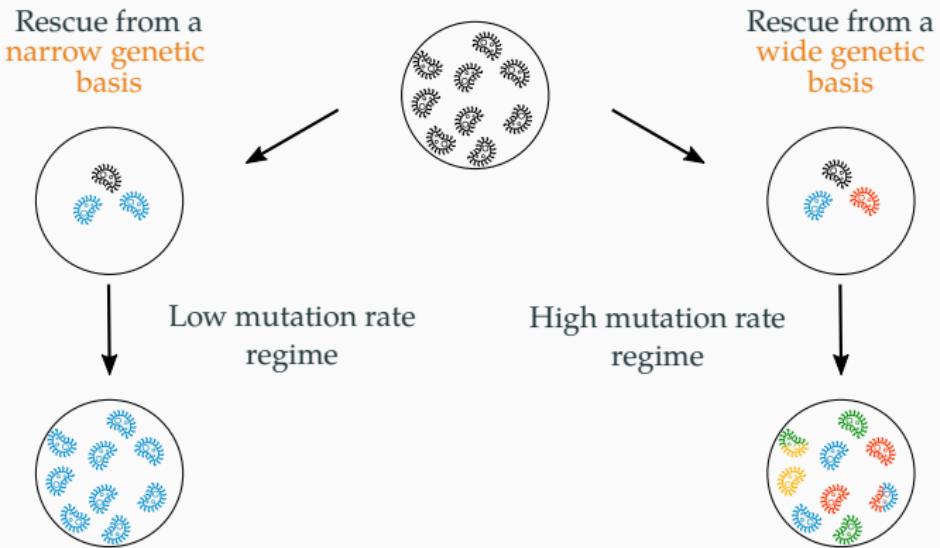


Two opposite mutation regimes



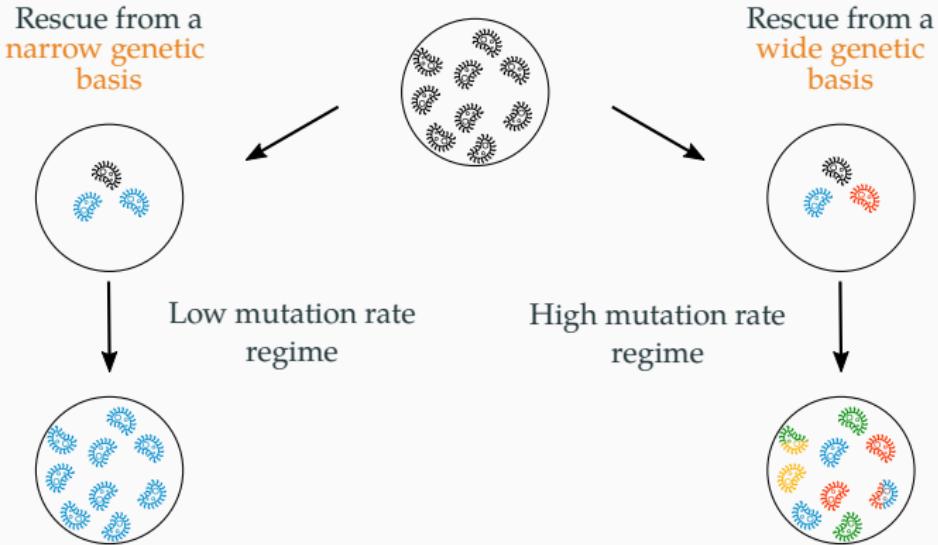
Model : "**Weak U**"
Stochastic demography
Stochastic evolution

Two opposite mutation regimes



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Stochastic demography
Stochastic evolution

Two opposite mutation regimes

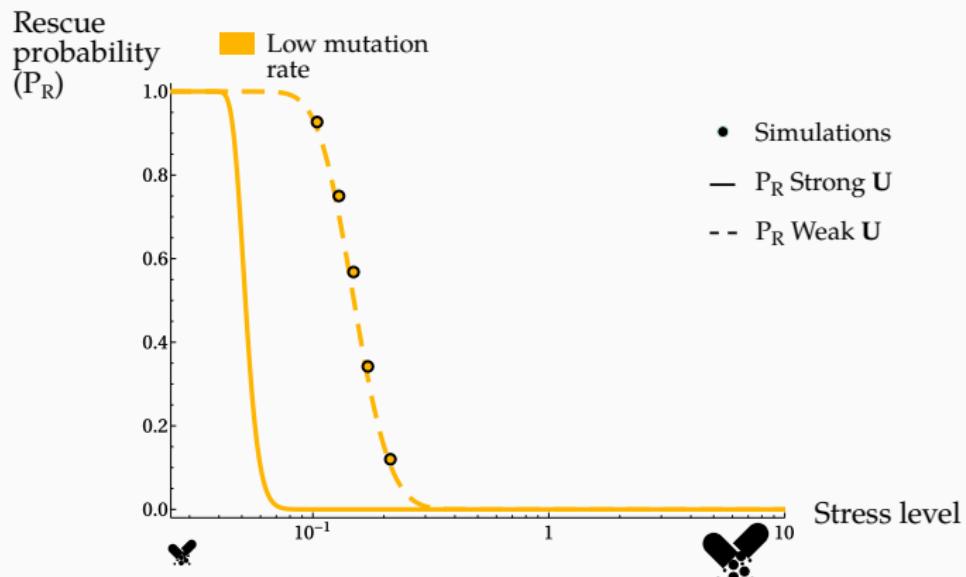


Model : "**Weak U**"
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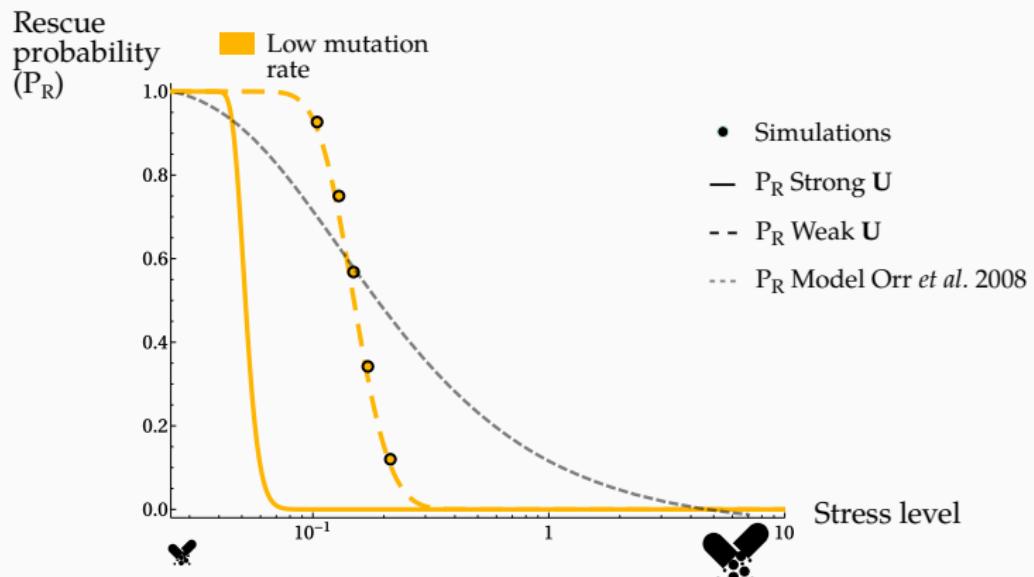
Model : "**Strong U**"
Stochastic demography
Deterministic evolution

Prediction of evolutionary rescue probabilities

Evolutionary rescue probability against environmental stress

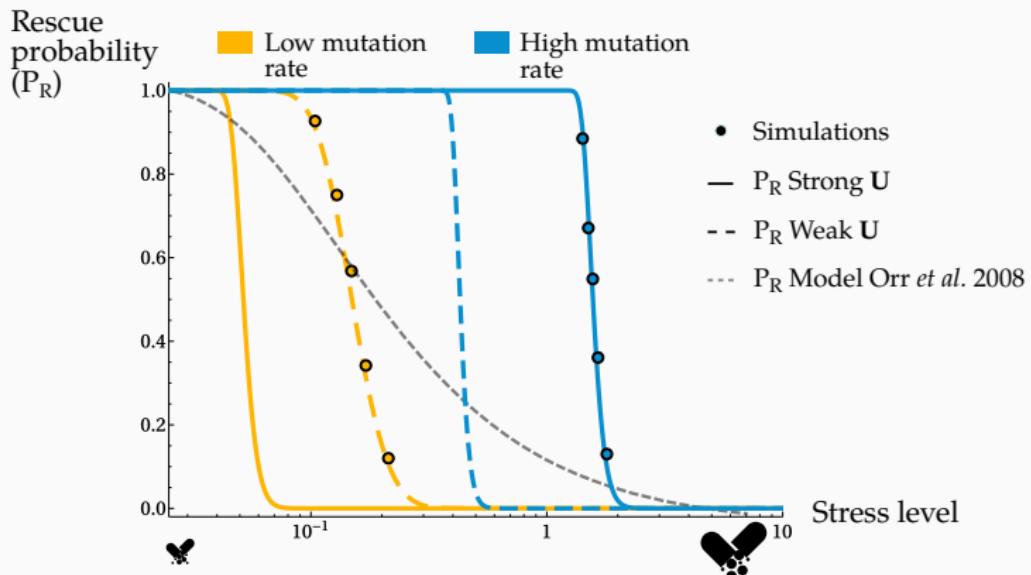


Evolutionary rescue probability against environmental stress



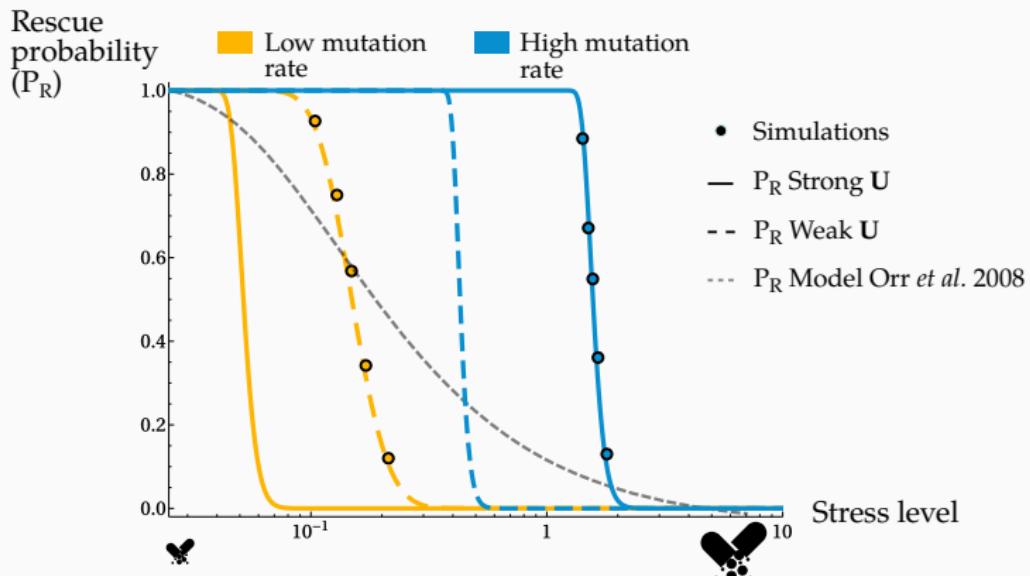
Evolutionary rescue probability against environmental stress

The models "Weak U" and "Strong U" gives good predictions against the simulations in **complementary mutation regimes**



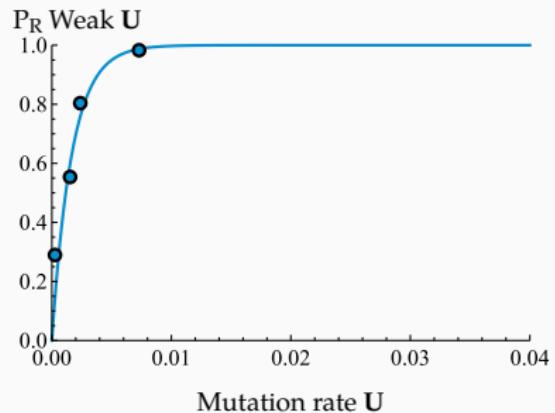
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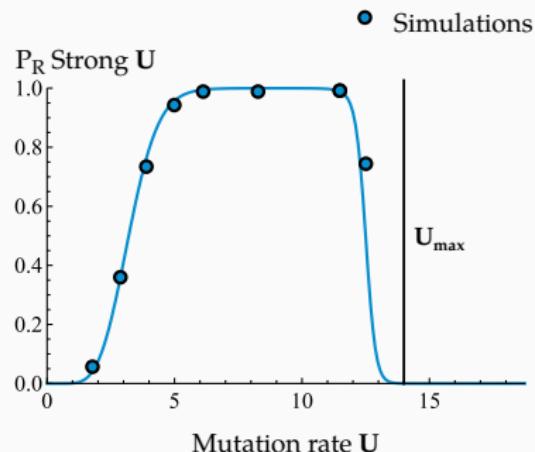
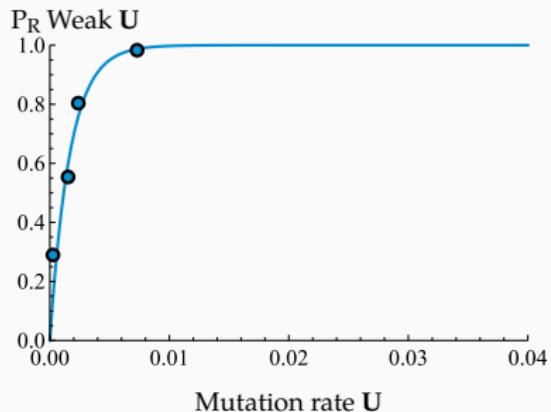


The "**Strong U**" model predicts that a population can withstand **higher stress** than the "**Weak U**" model

Evolutionary rescue probability against mutation rate



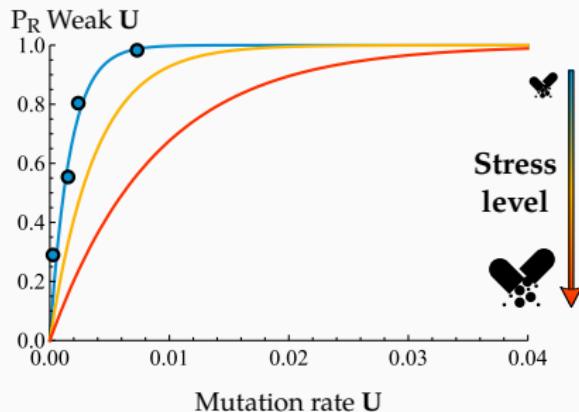
Evolutionary rescue probability against mutation rate



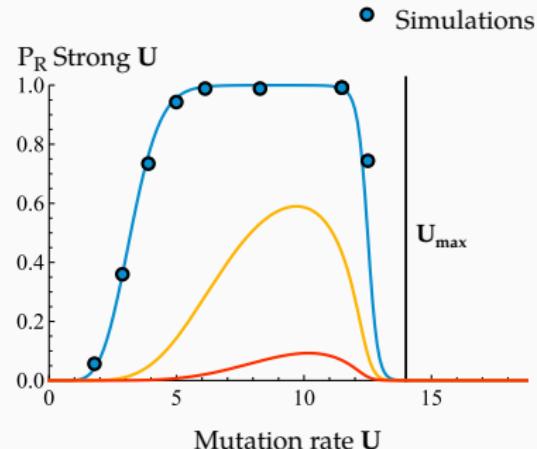
In the "Strong U" regime:

high mutation rates lead to lethal mutagenesis

Evolutionary rescue probability against mutation rate



Stress
level



● Simulations



In the "Strong U" regime:

high mutation rates lead to lethal mutagenesis

Increasing the stress decreases the maximal ER probability

Evolutionary rescue probability against mutation rate

Sharper drop of ER probability with context-dependence

Lethal mutagenesis emerges in populations with large mutation rates adapting in the "Strong U" regime.

Evolutionary rescue probability against mutation rate

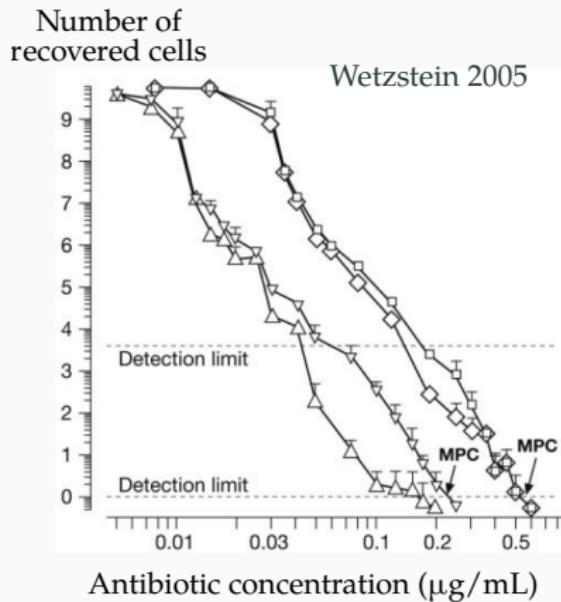
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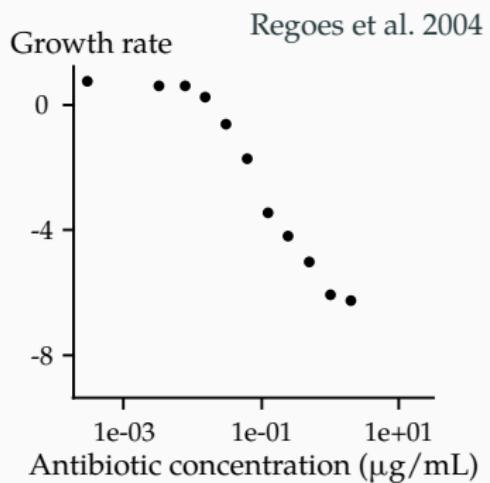
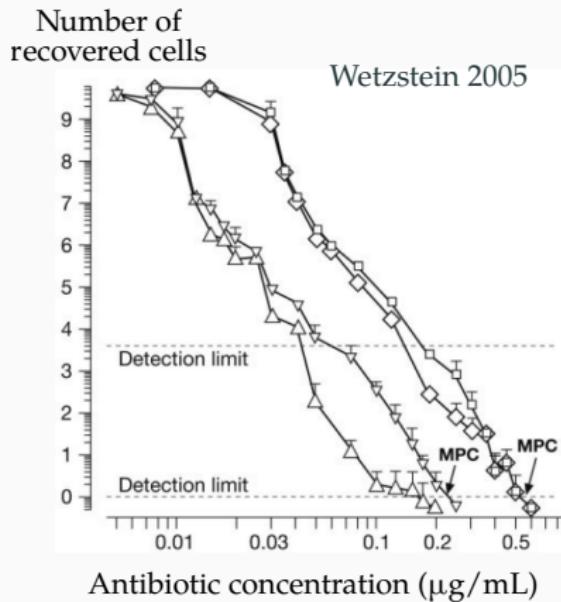
Results qualitatively similar with standing genetic variance

Preliminary results on data analysis

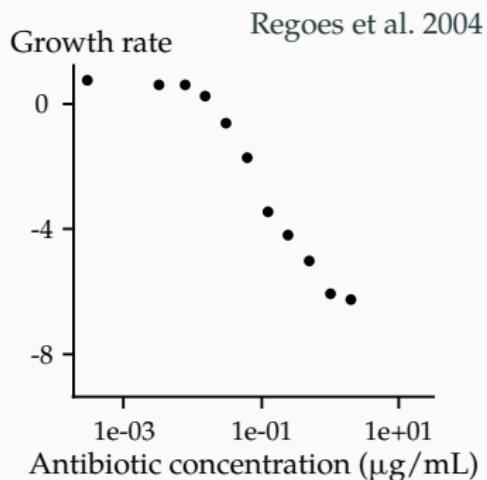
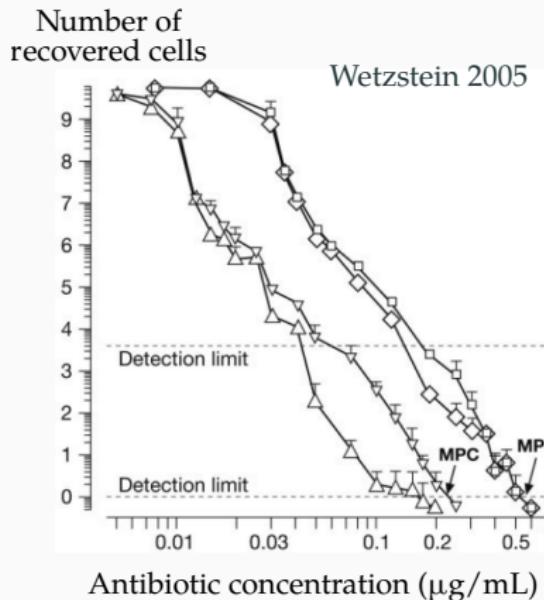
Available data



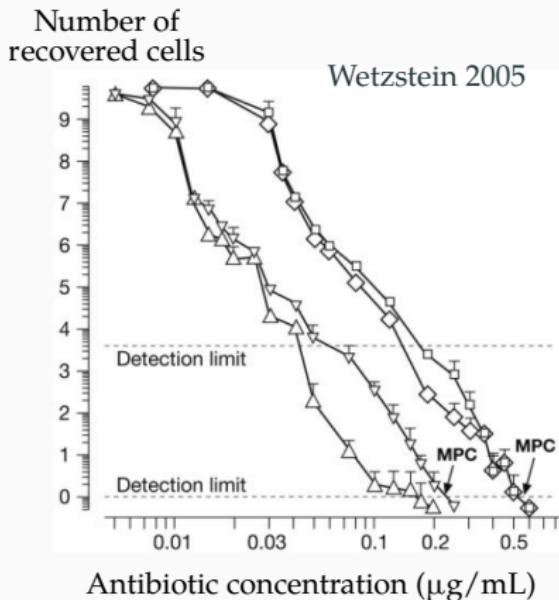
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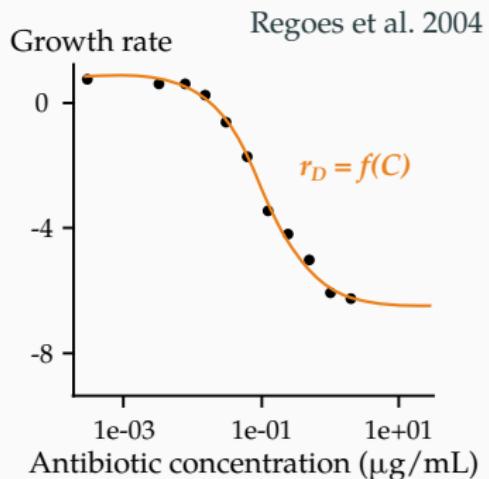
Available data



Available data



Relationship between antibiotic concentration C and decay rates r_D

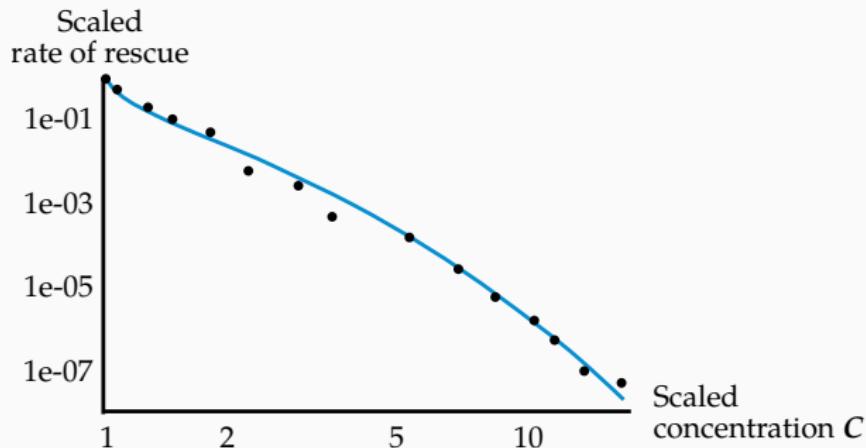


Available data

Model "Weak U" $r_D = f(C)$

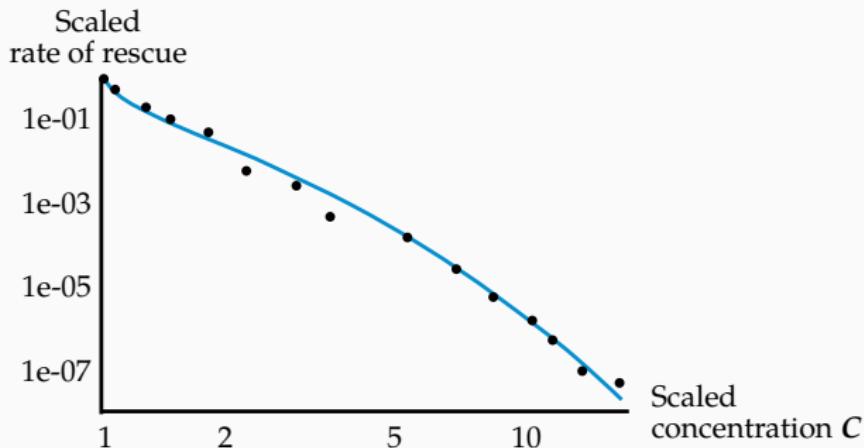
Available data

Model "Weak U" $r_D = f(C)$



Available data

Model "Weak U" $r_D = f(C)$



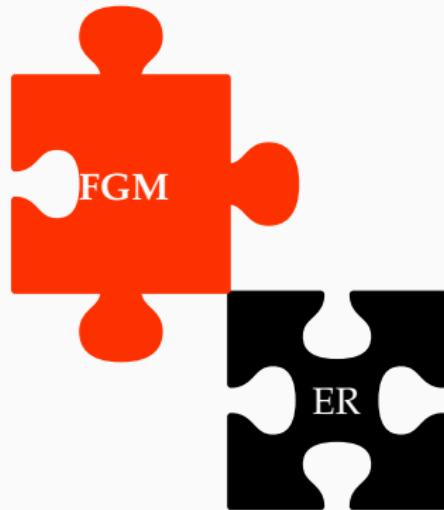
The model combining the "Weak U" model and the function $r_D = f(C)$ has too many parameters.

The model gives a better visual fit than a model without context-dependence

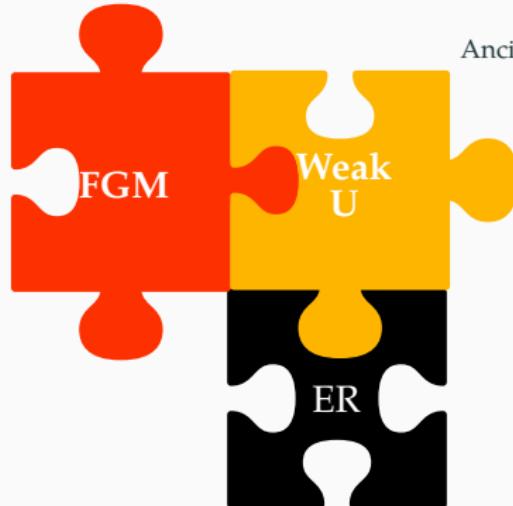
Conclusions and Perspectives



Conclusions and Perspectives



Conclusions and Perspectives



Anciaux *et al.* (2018)

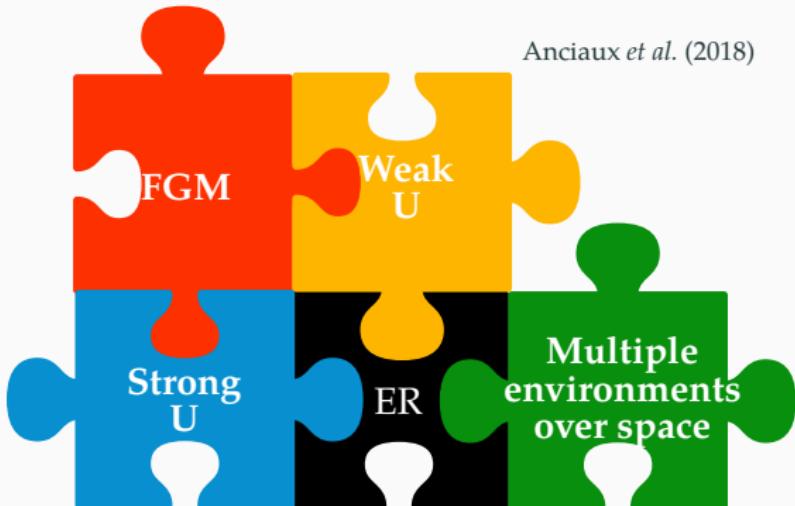
Conclusions and Perspectives



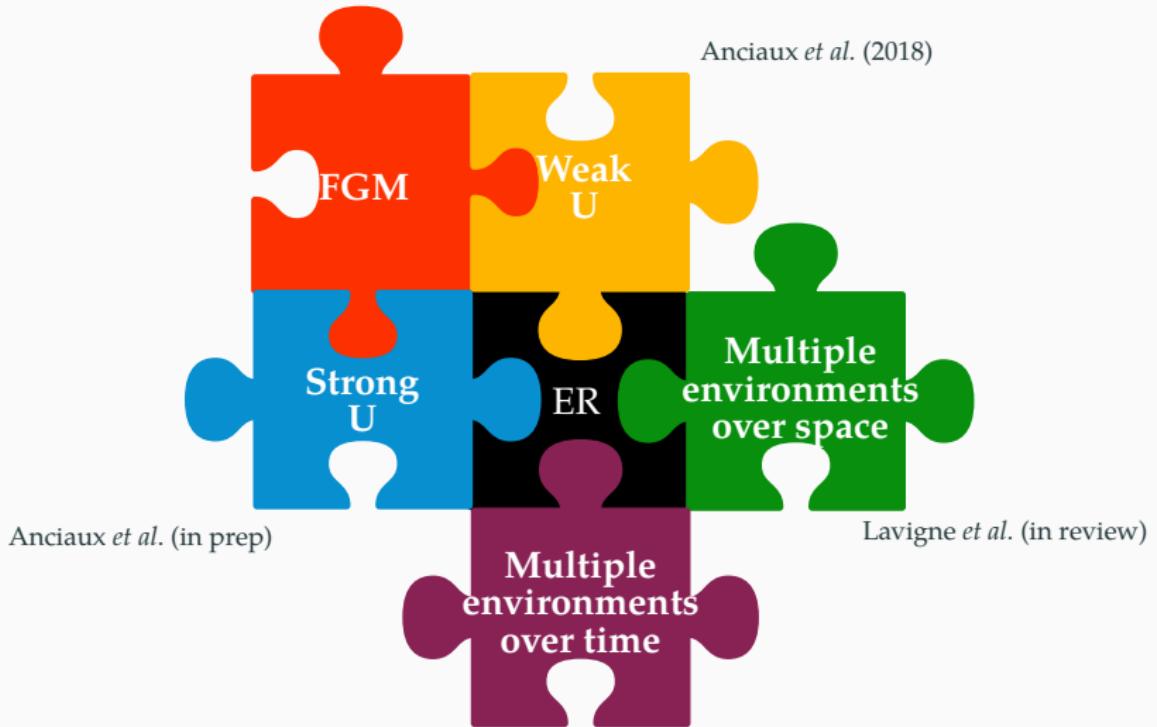
Anciaux *et al.* (2018)

Anciaux *et al.* (in prep)

Conclusions and Perspectives



Conclusions and Perspectives



Thanks

THANK YOU !

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