

# The maintenance of sex

# The problem

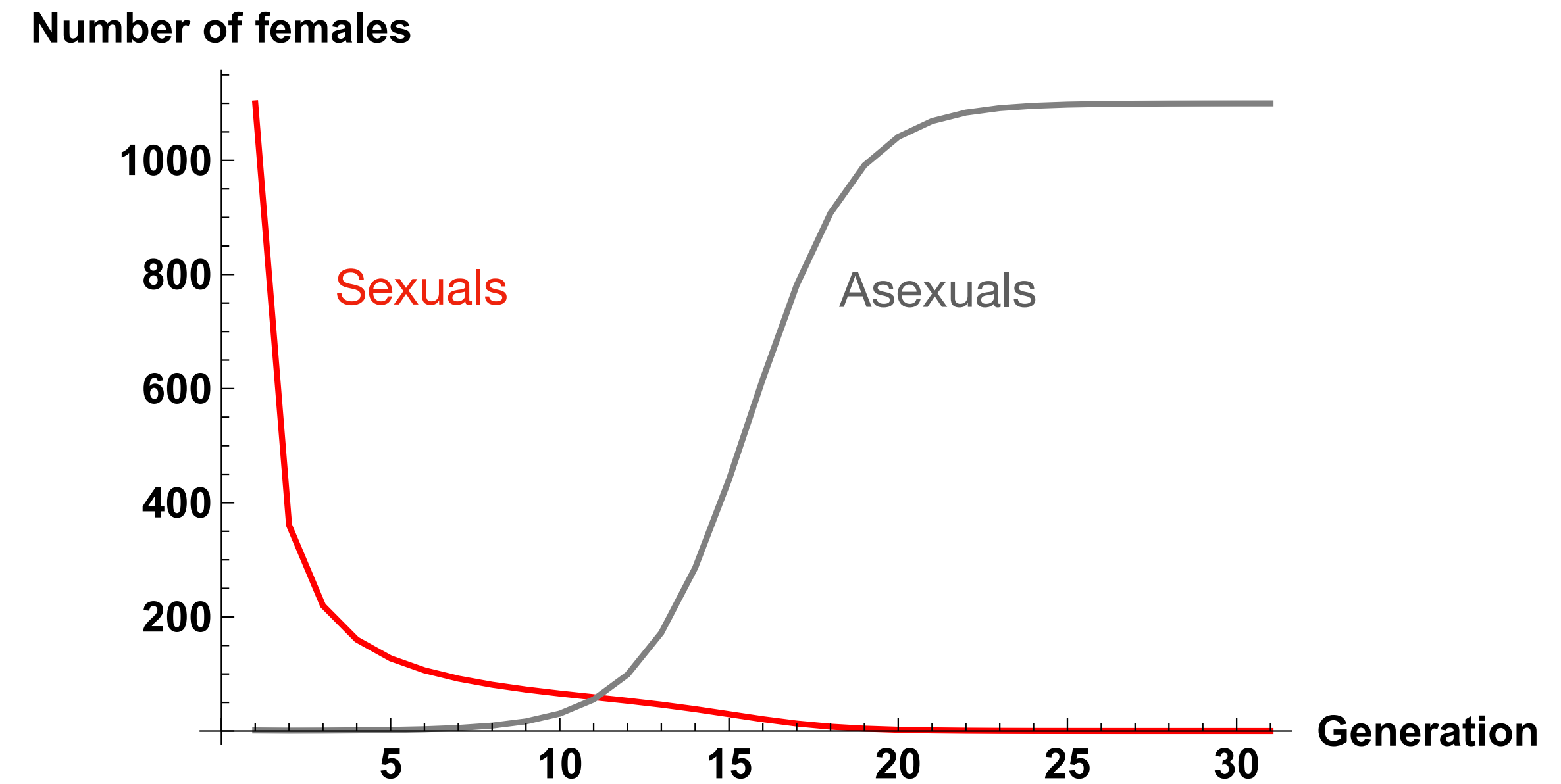
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- Rapid demographic advantage versus slow evolutionary cost of asexuality

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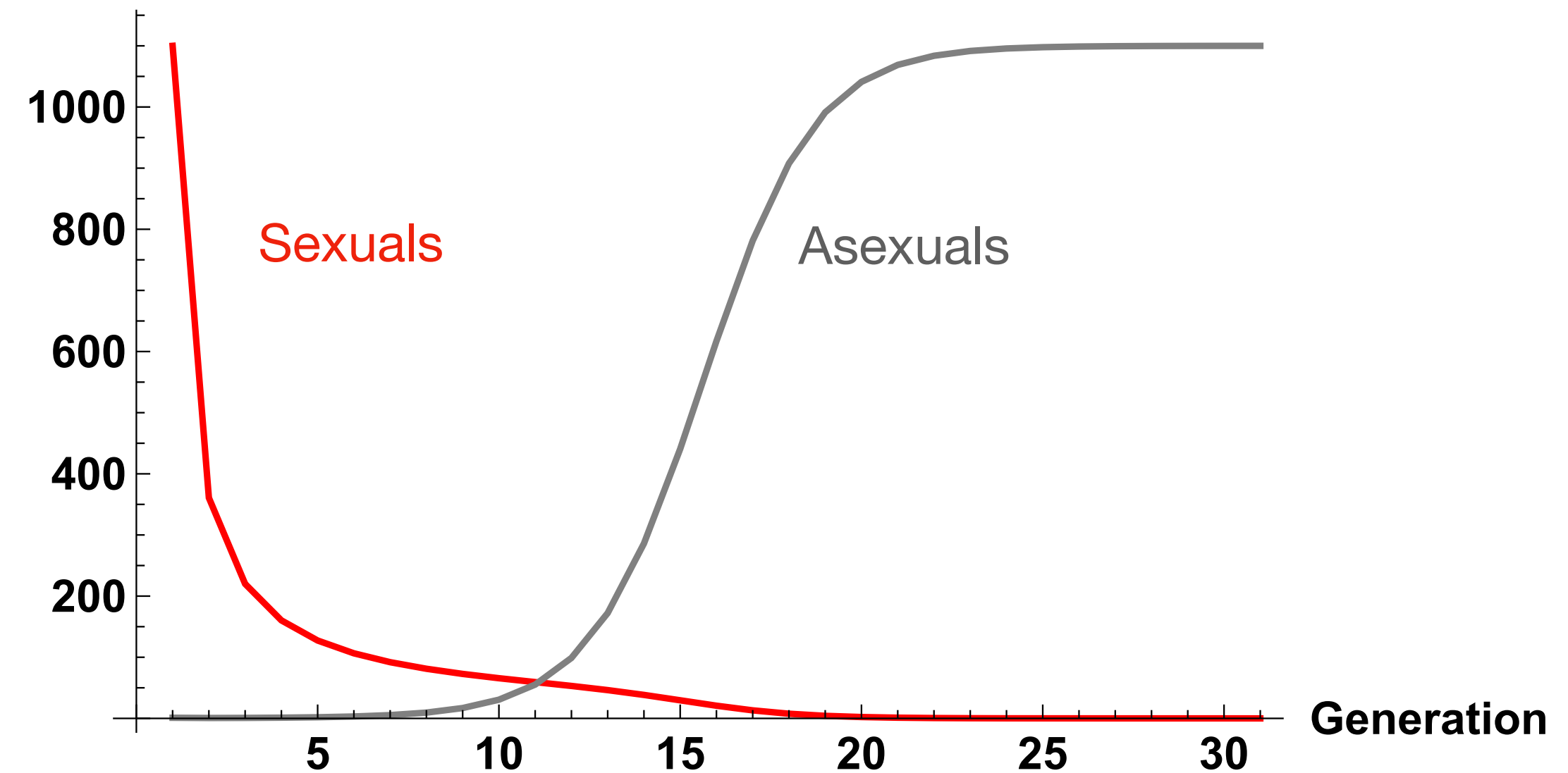


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## How to overcome to twofold cost?

- Rapid demographic advantage versus slow evolutionary cost of asexuality

Number of females



Fecundity

$$f(k) \propto (1 - s)^k$$

Number of deleterious mutations

Effect of single mutation

$$\frac{f_A(k_A)}{f_S(k_S)} < \frac{1}{2} \iff (1 - s)^{k_A - k_S} < \frac{1}{2}$$

condition for maintenance of sex due to deleterious mutations

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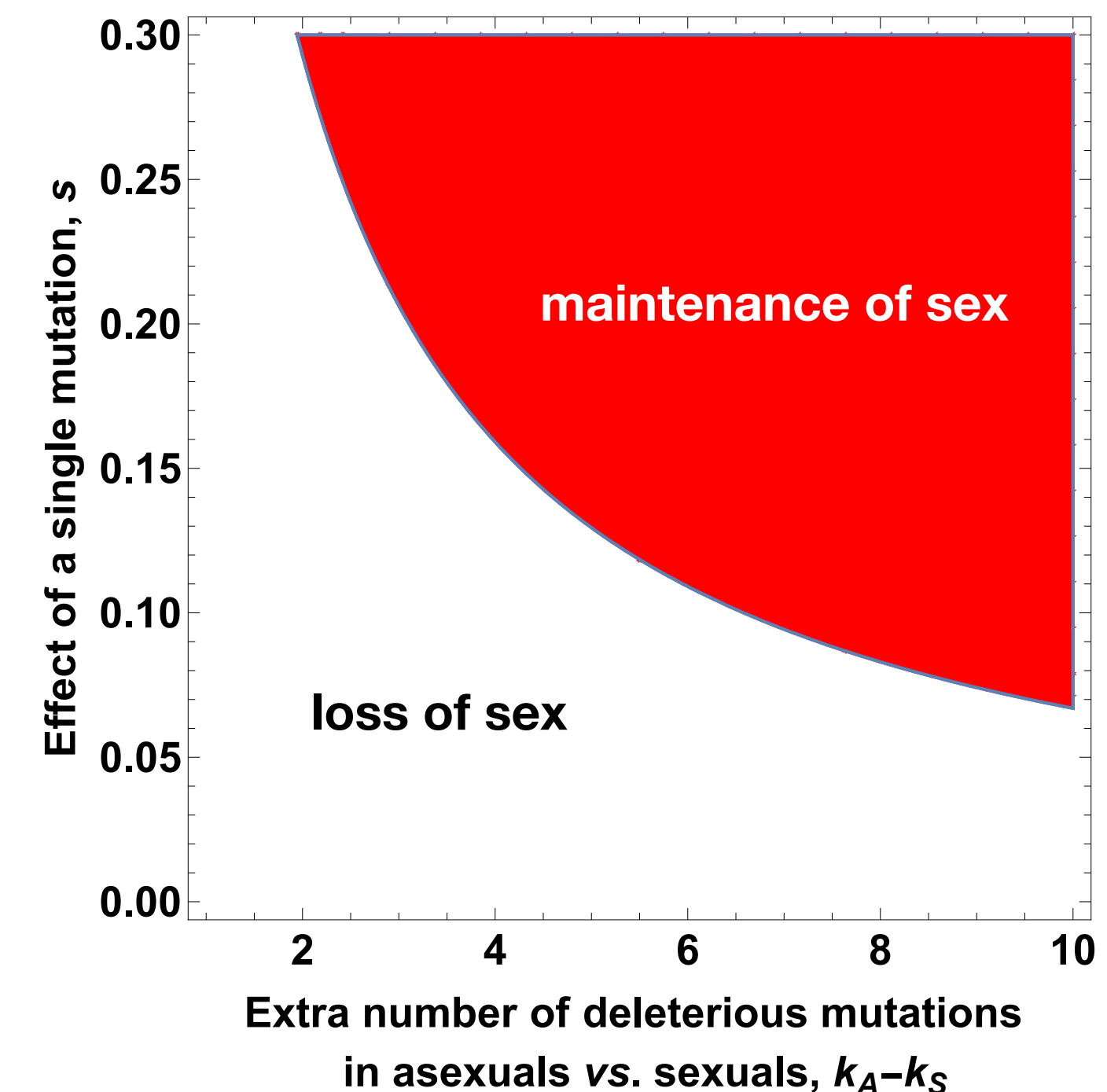
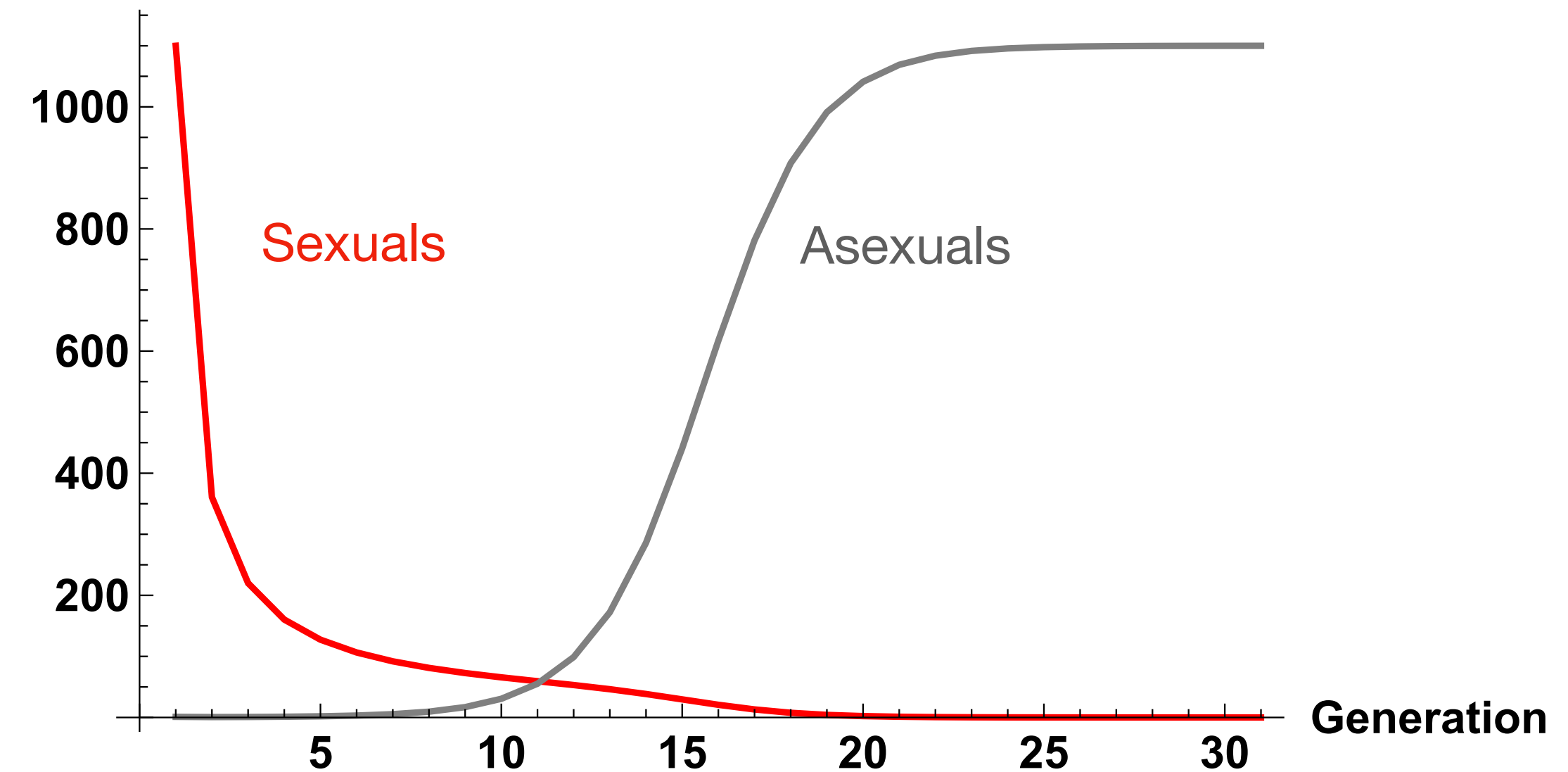
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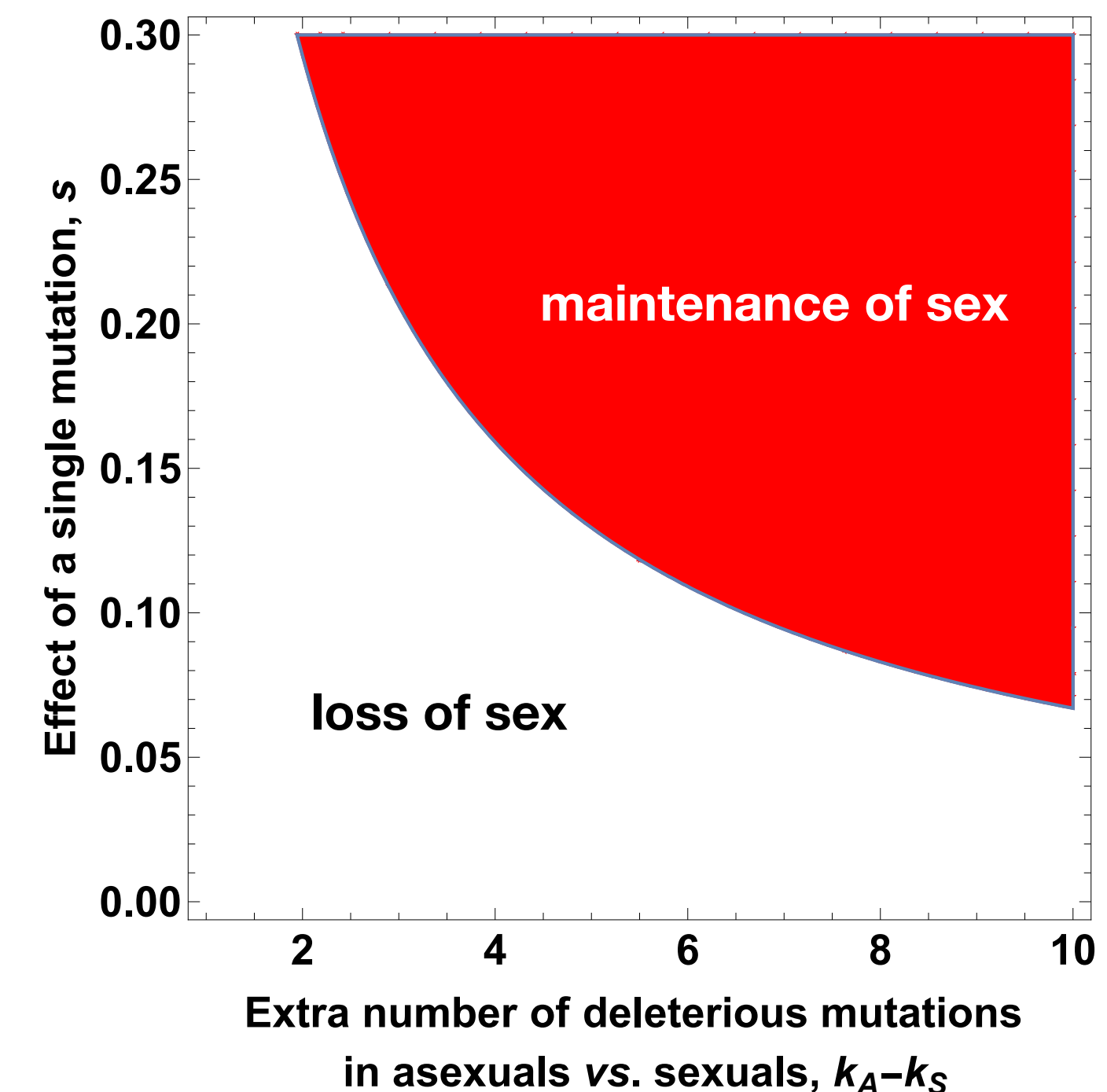
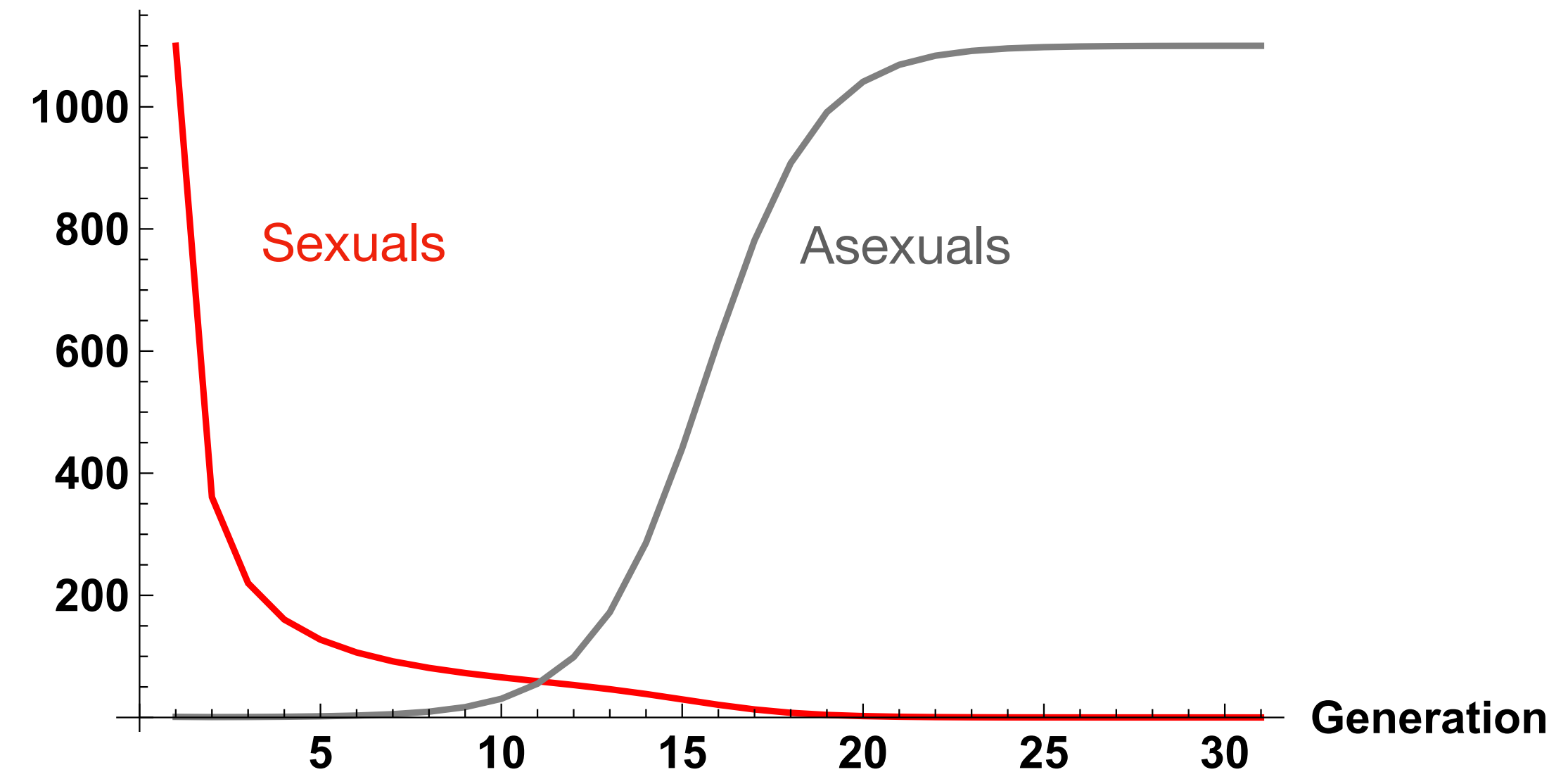
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## How to overcome to twofold cost?

- Rapid demographic advantage versus slow evolutionary cost of asexuality

Assuming an asexual is initially equivalent to a sexual, deleterious mutations must accumulate impossibly fast or have unrealistically large fitness effects for sexuality to be maintained.

Number of females

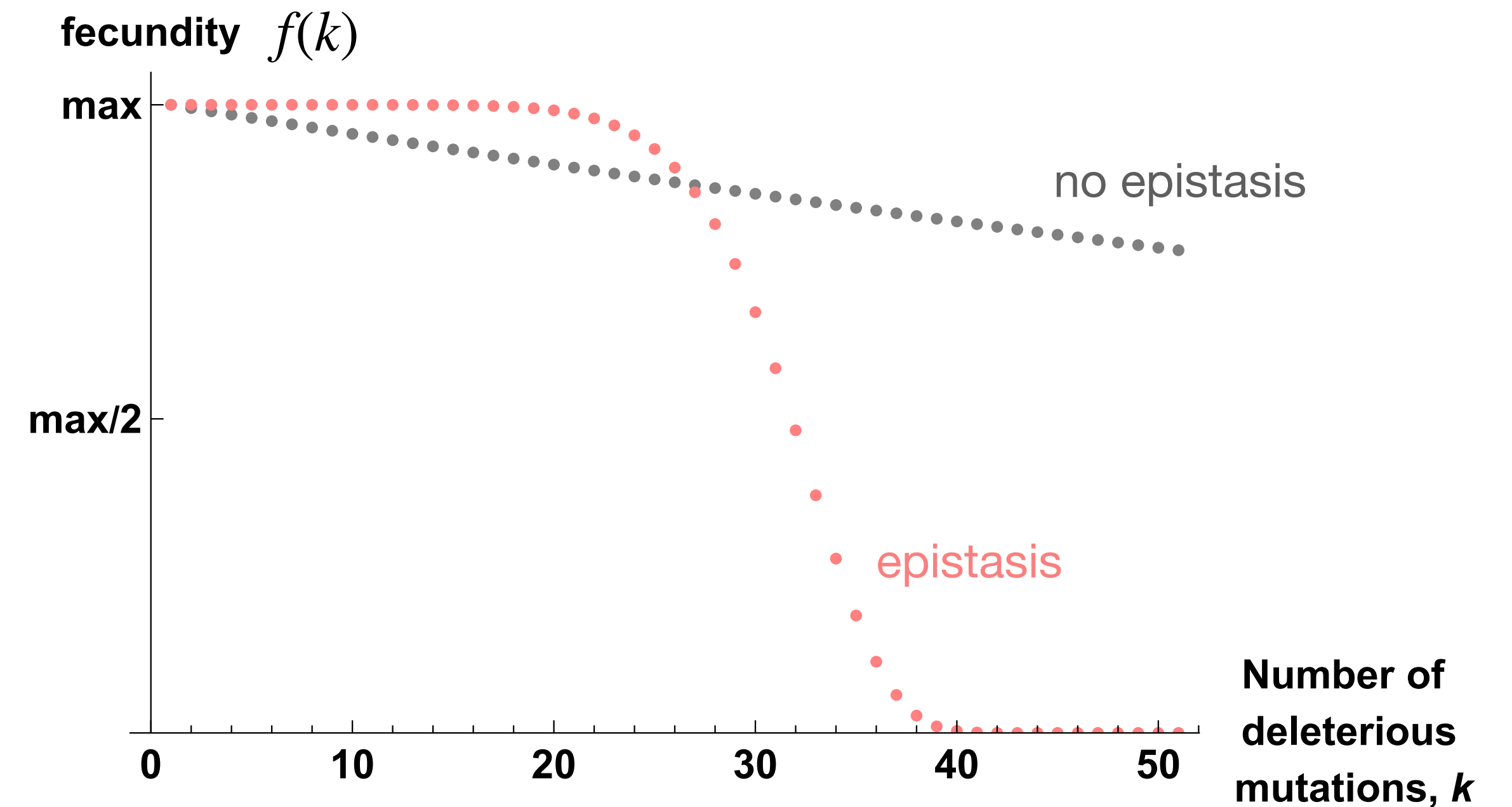


# Can strong epistasis rescue sexuals?

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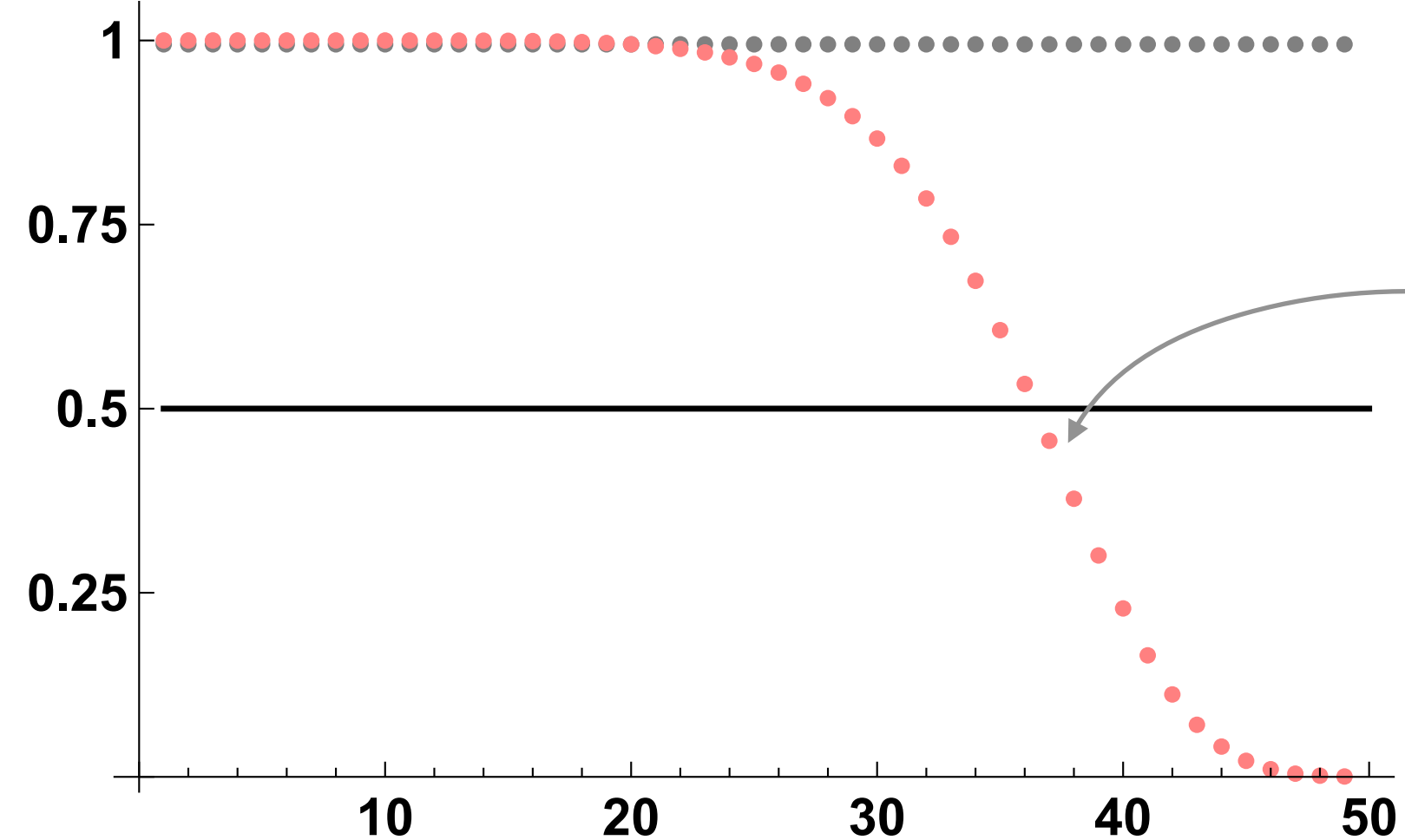




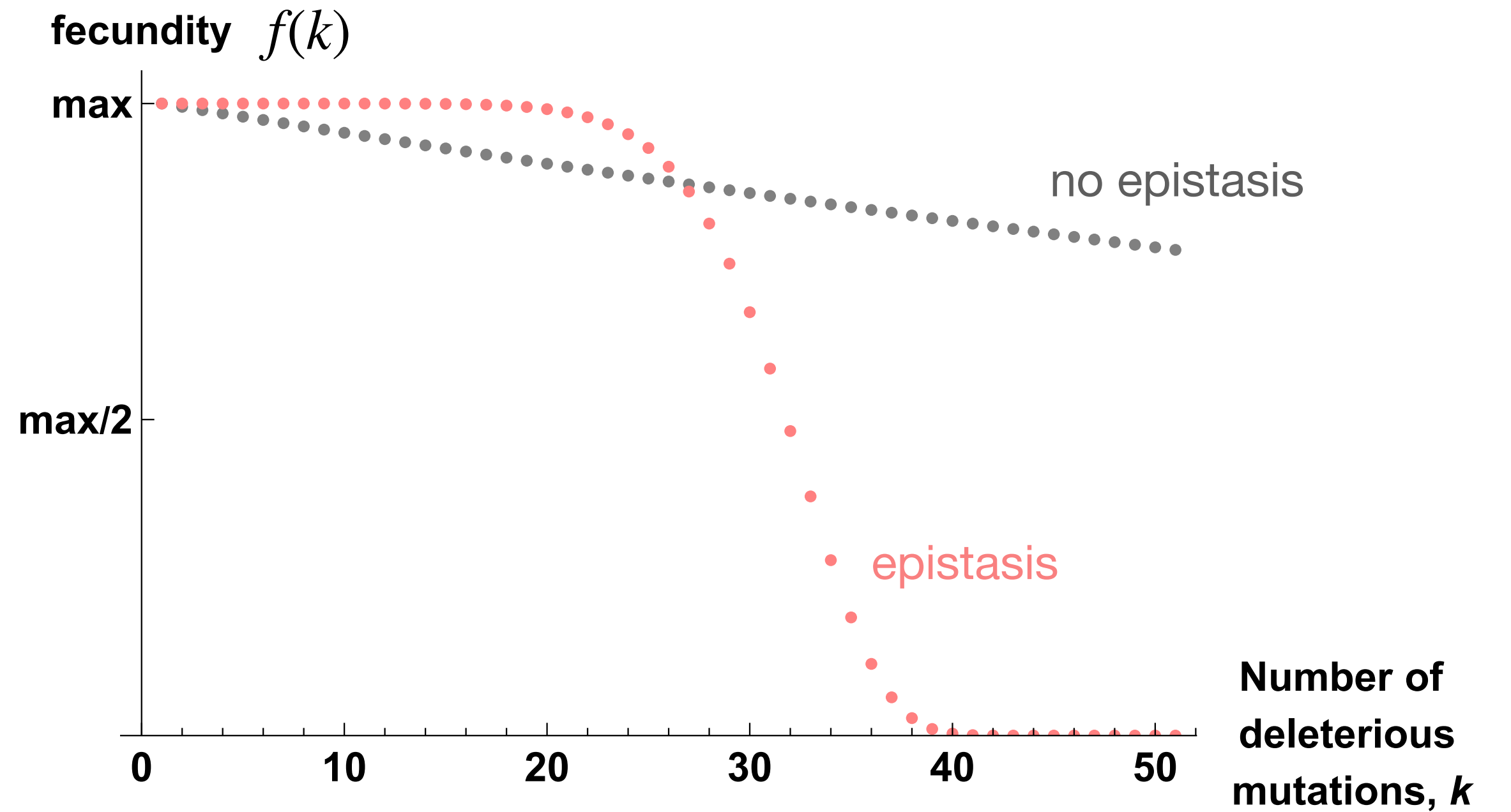
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Fecundity effect of one extra mutation  $f(k+1)/f(k)$

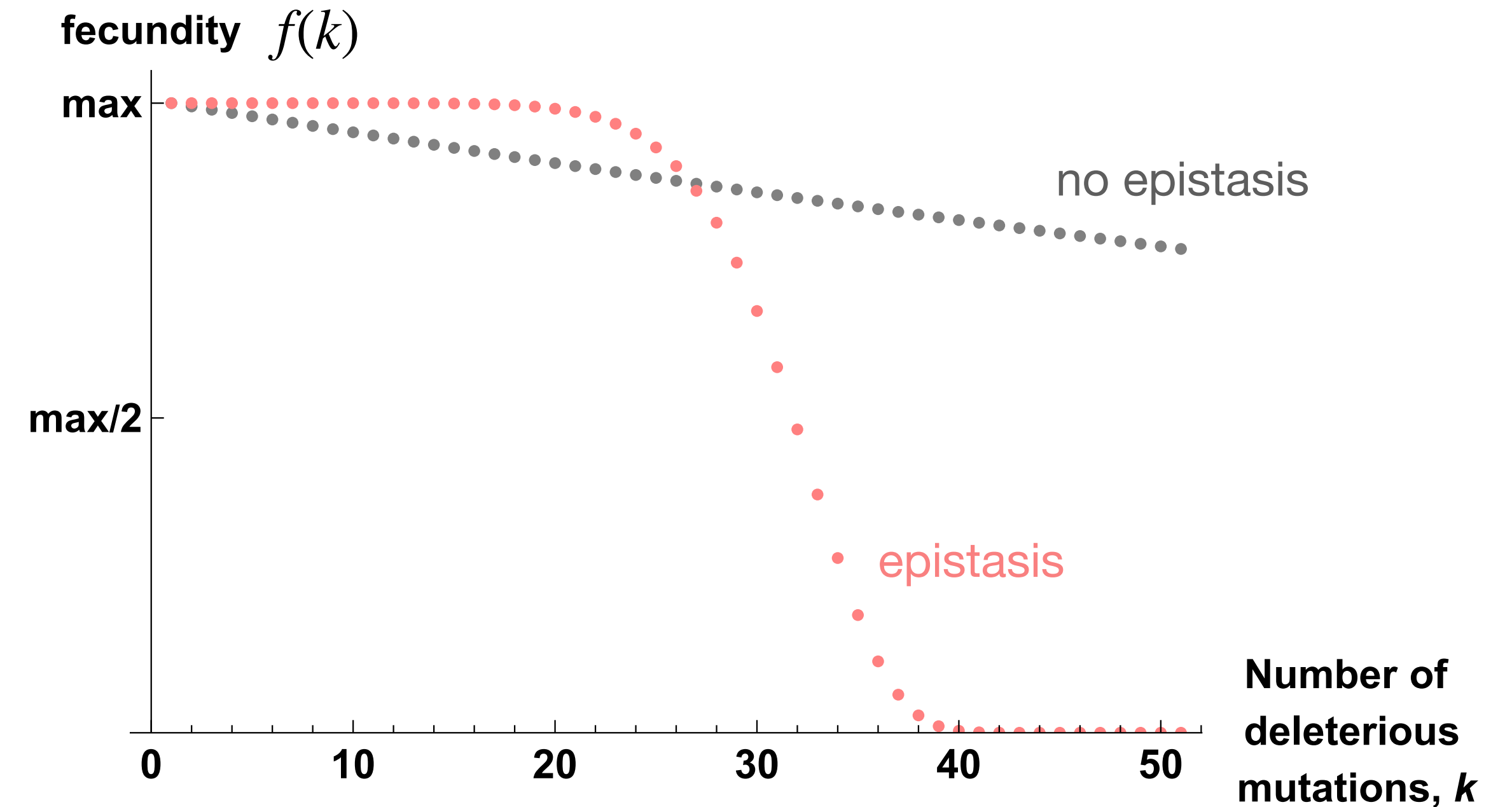
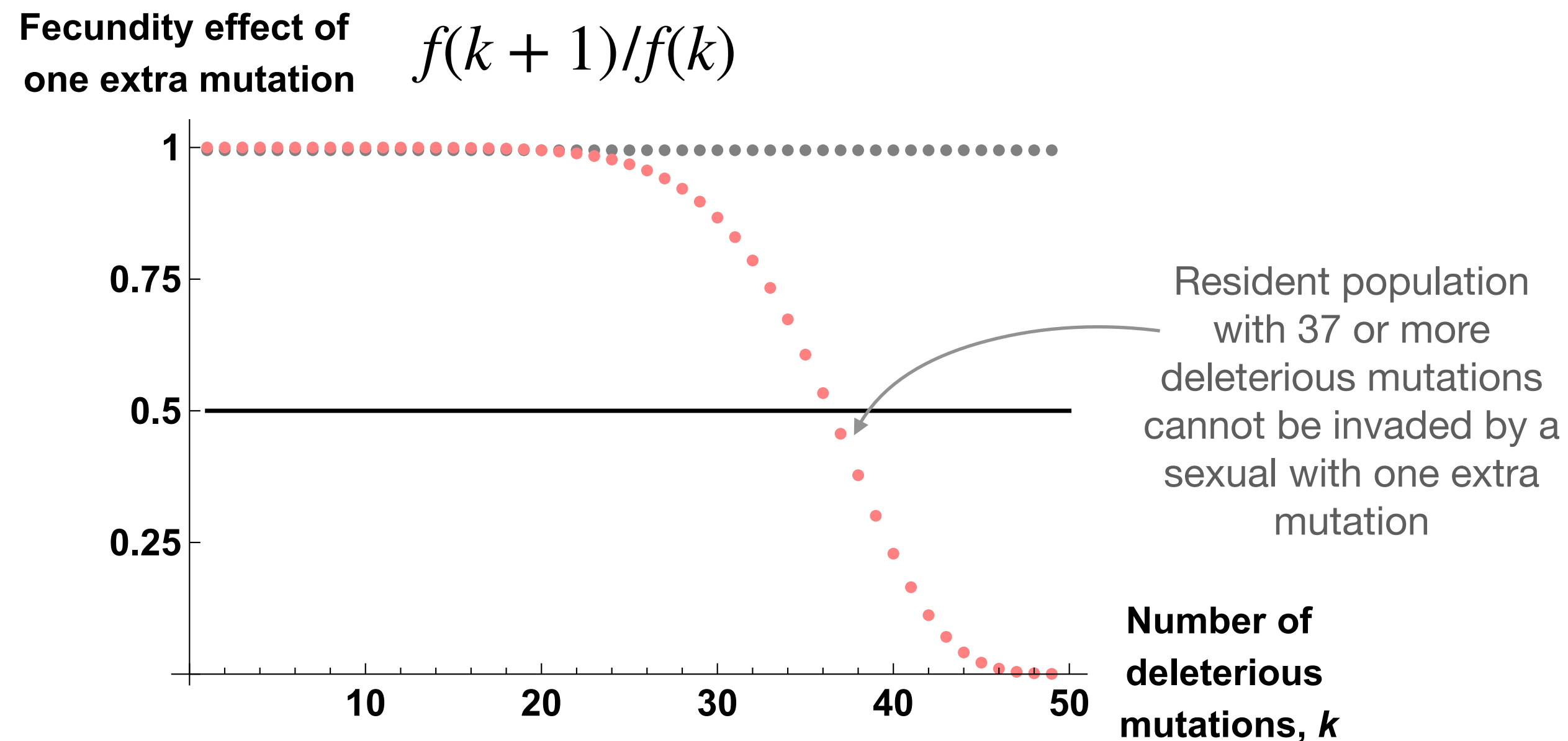


Resident population with 37 or more deleterious mutations cannot be invaded by a sexual with one extra mutation



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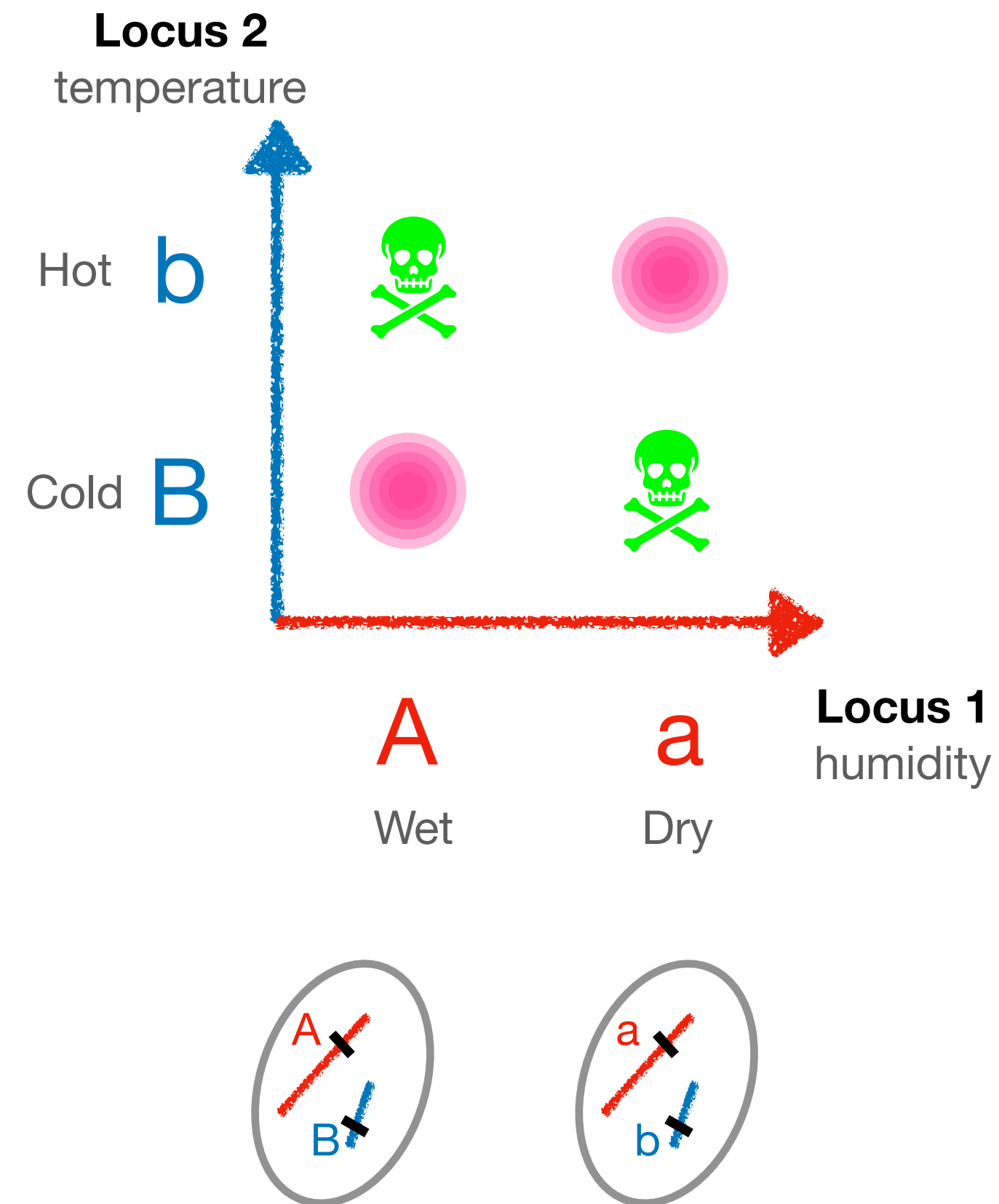


- Works if sexual population already quite loaded with mutations
- See exercise sheet 5

# Fluctuating epistasis

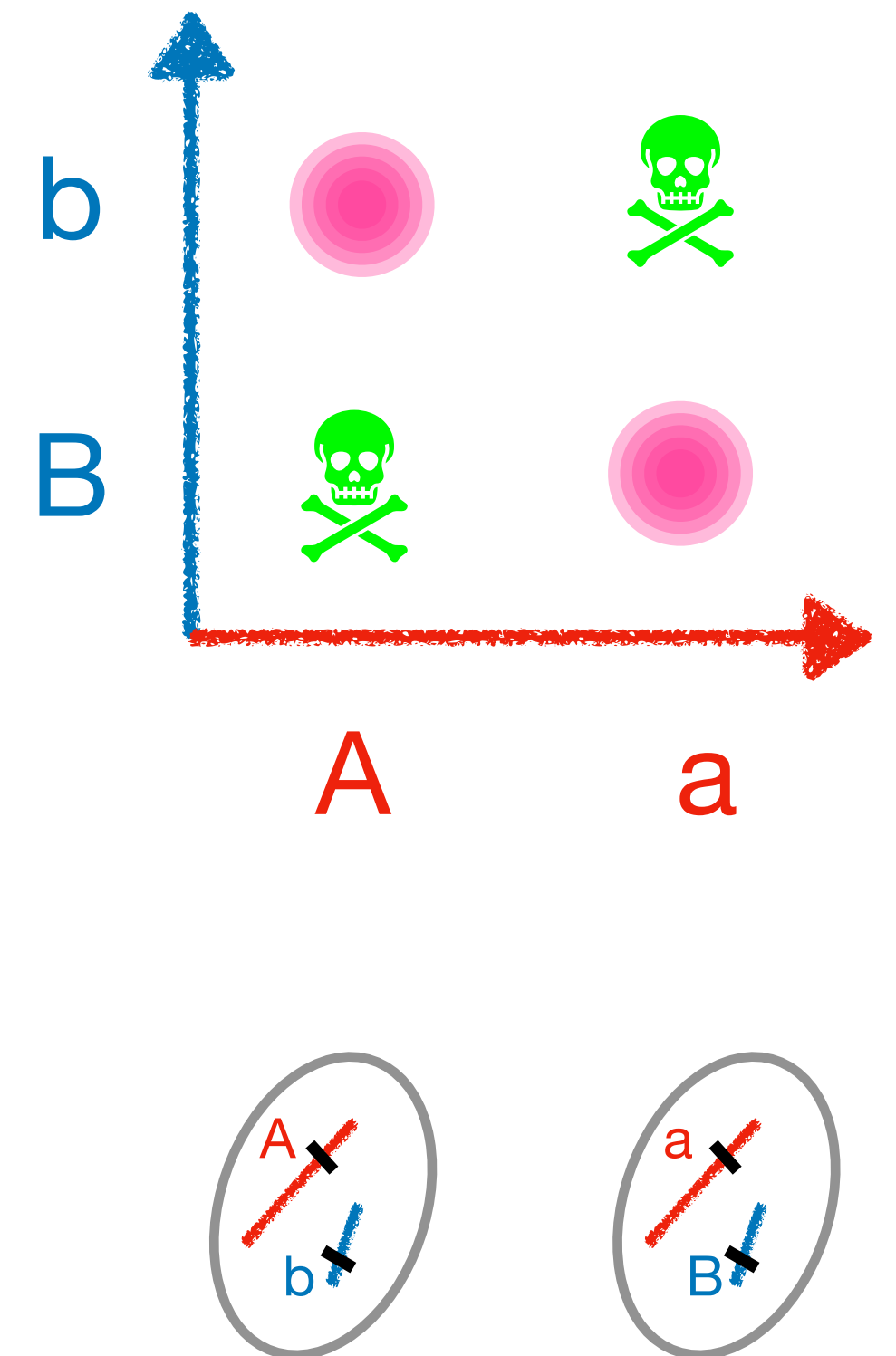
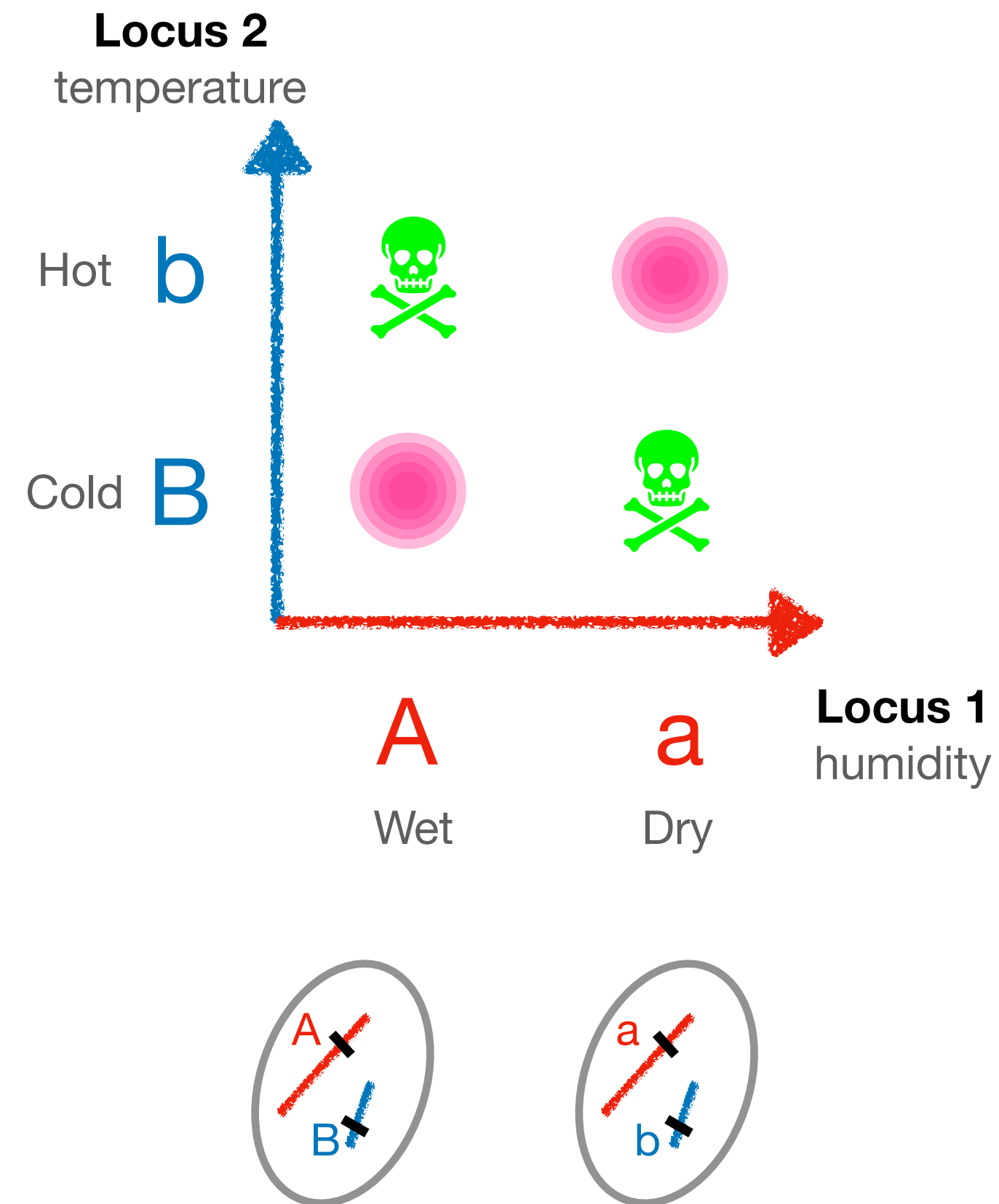
# Fluctuating epistasis

- Environment favours specific allelic associations



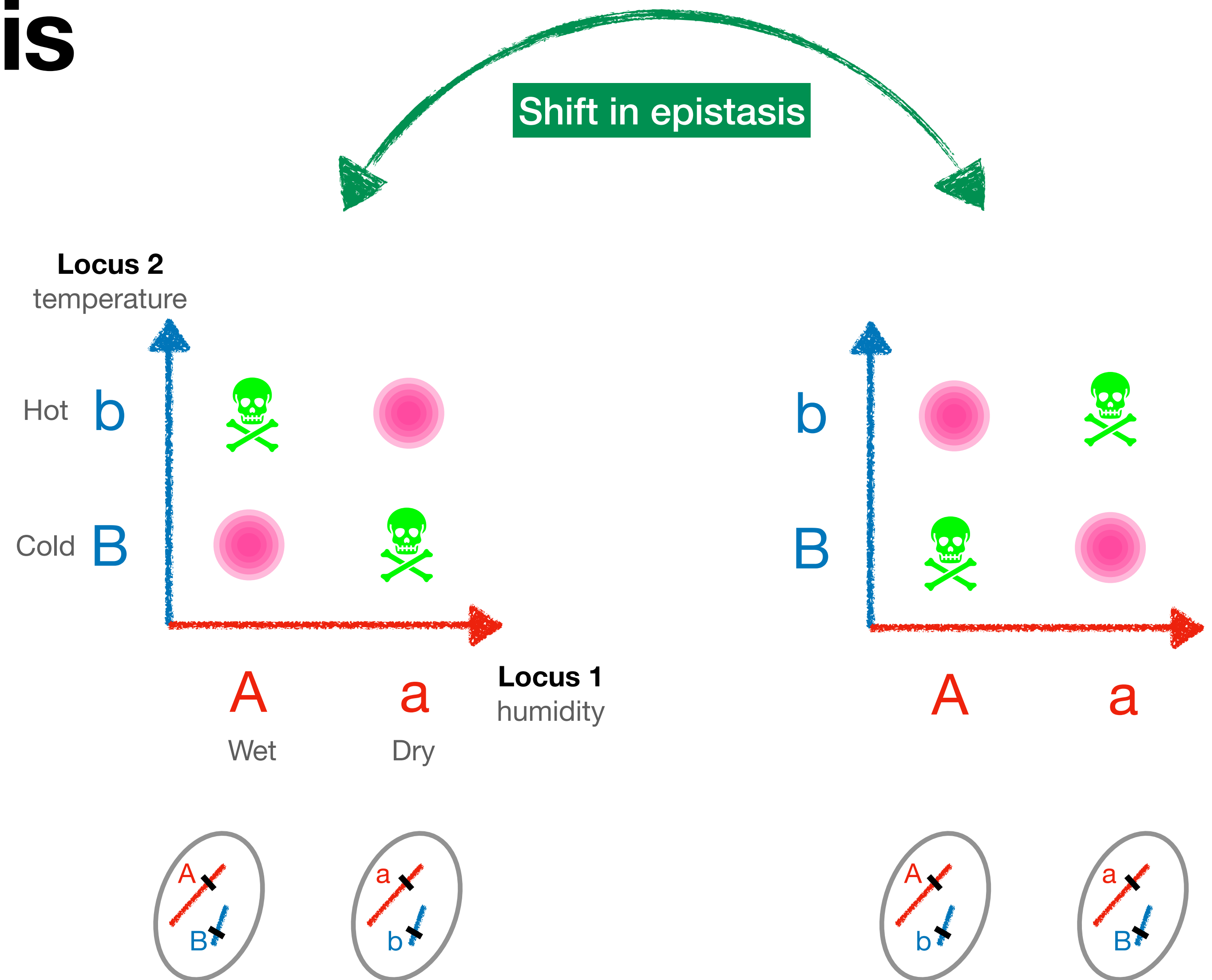
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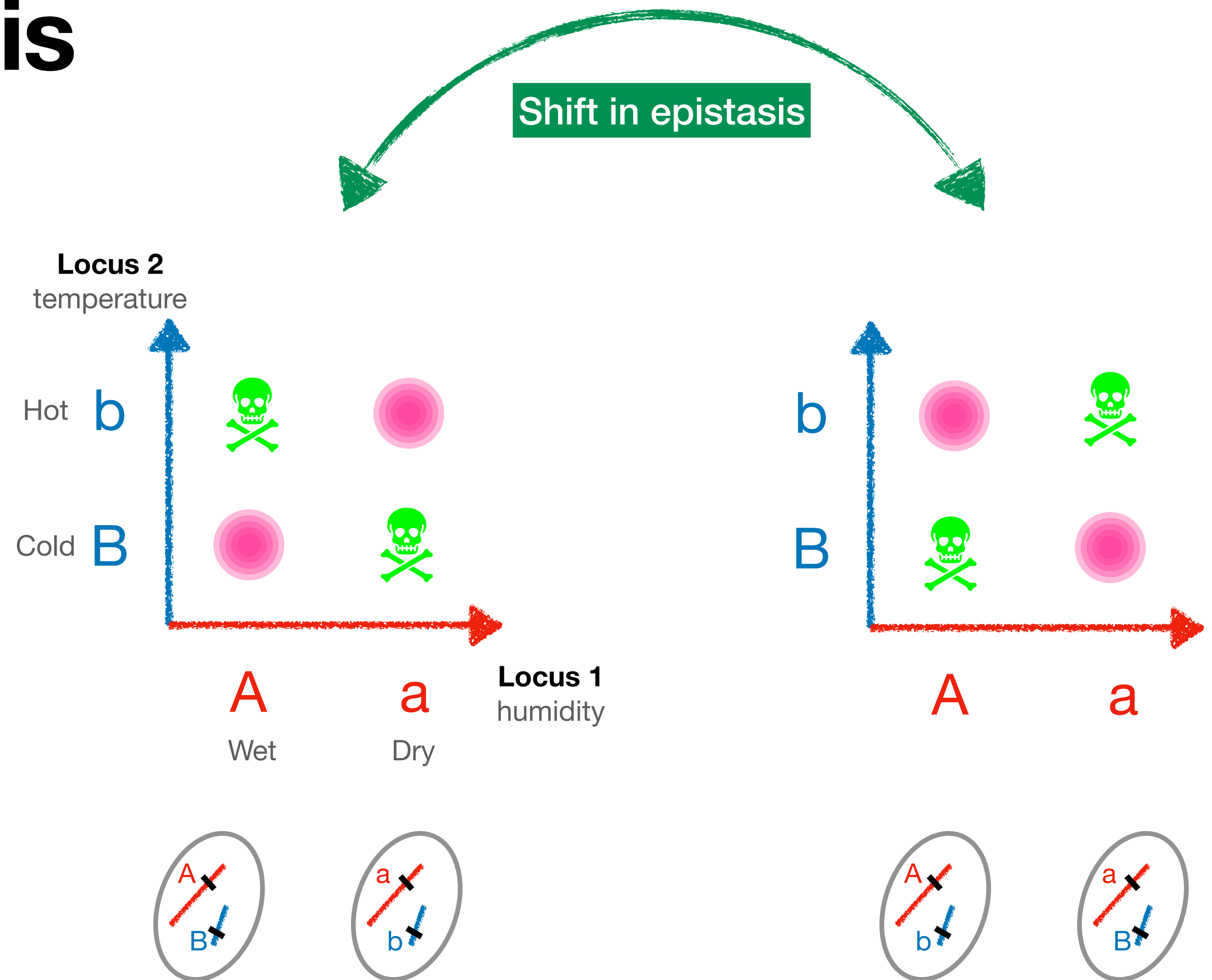
# Fluctuating epistasis

- Environment favours specific allelic associations
- The environment fluctuates in time, favouring different associations at different times



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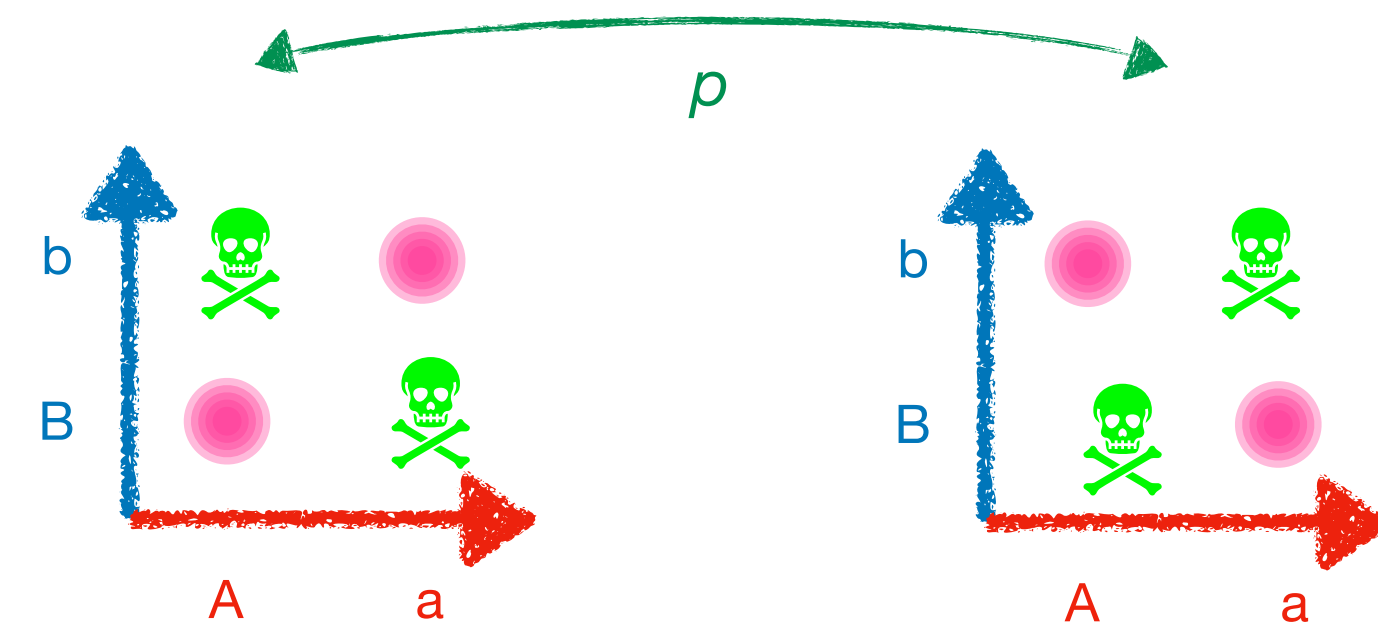
- Environment favours specific allelic associations
- The environment fluctuates in time, favouring different associations at different times
- Asexuals should lose out as the allelic associations of an asexual lineage are fixed



# Fluctuating epistasis

## Example

- Population with two types of habitats, each favouring a specific combination of alleles.
- Combination changes at each generation with probability  $p$ .
- Start with a population of sexuals. Introduce asexuals through mutation.

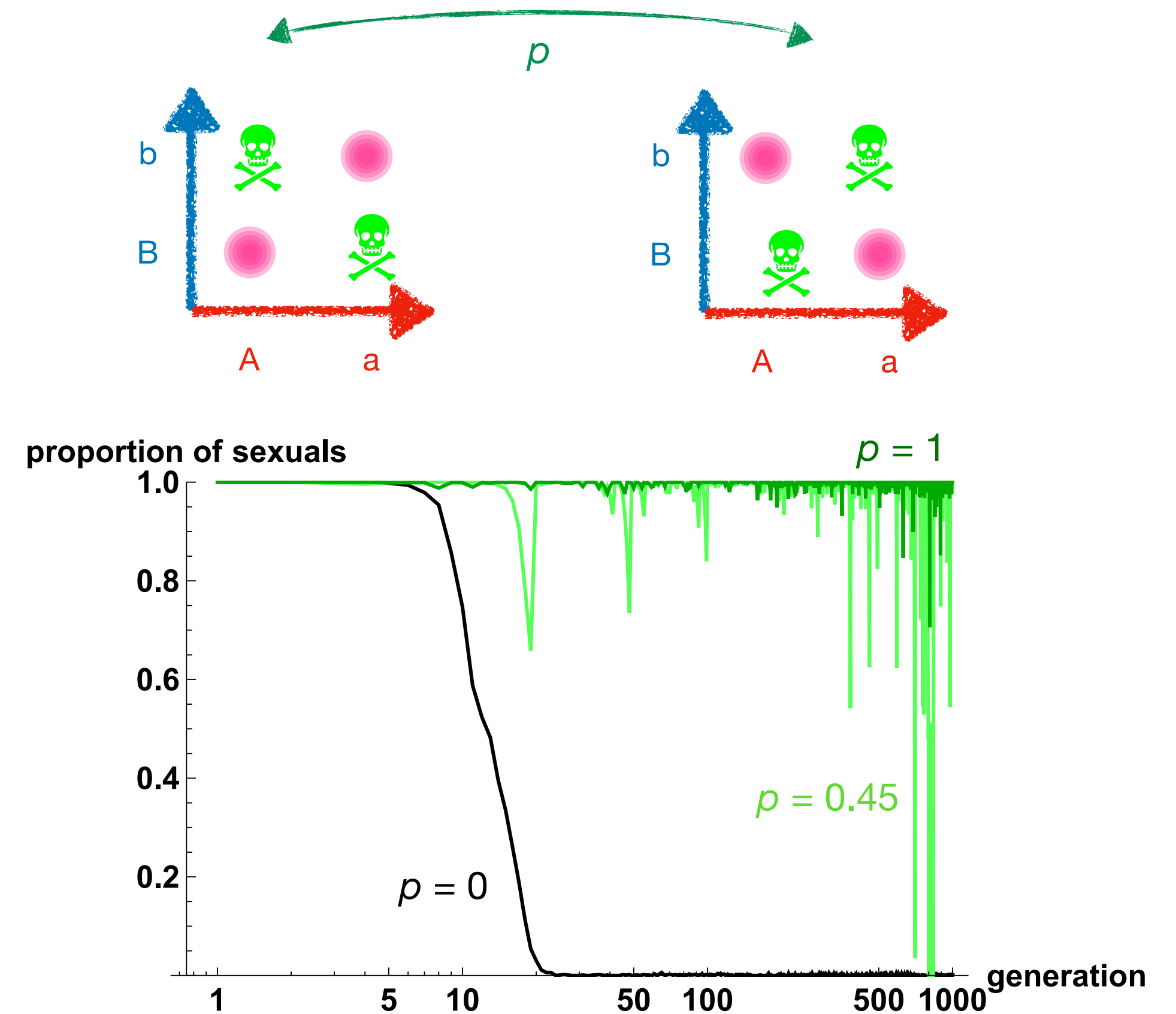




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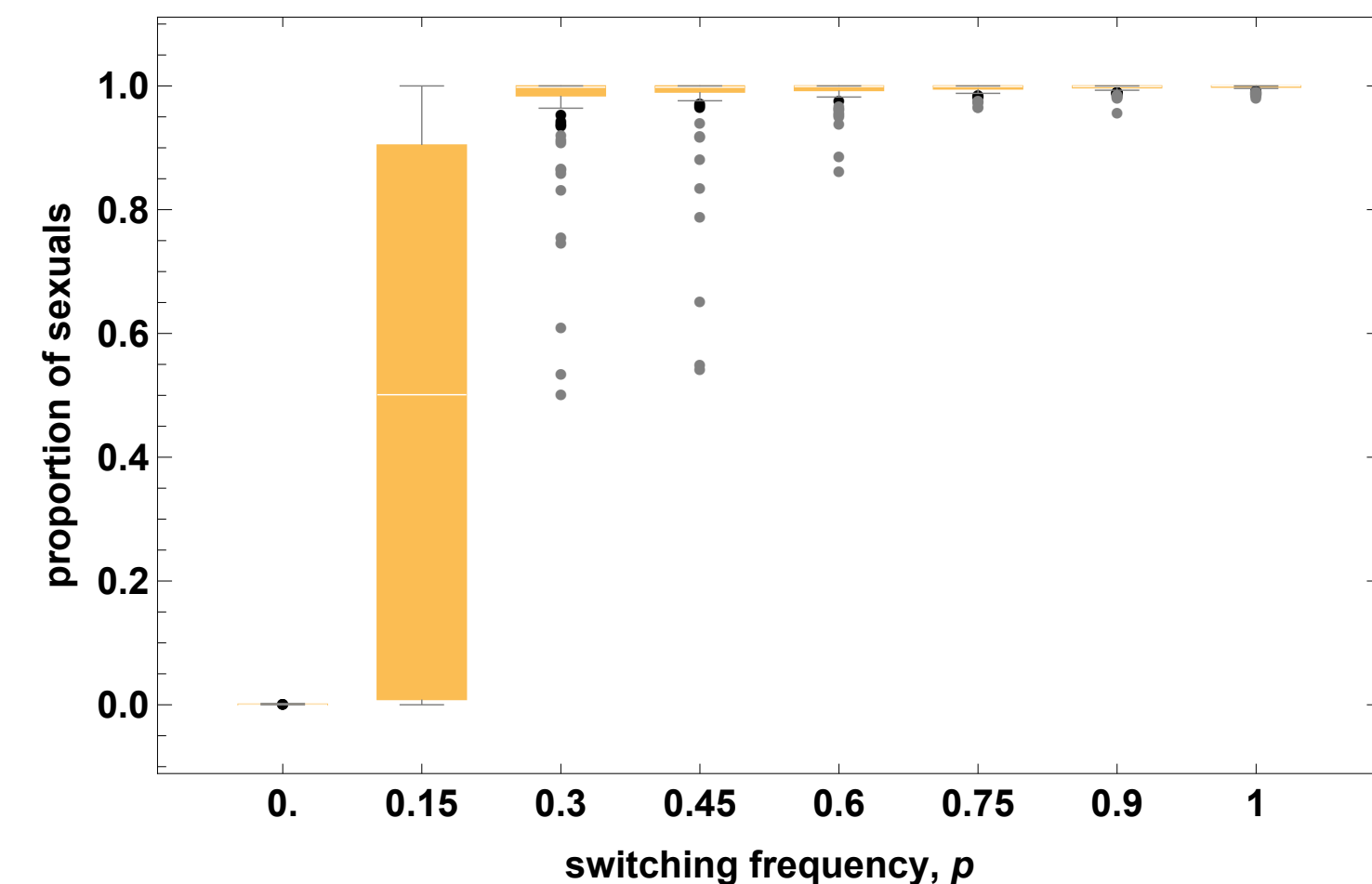
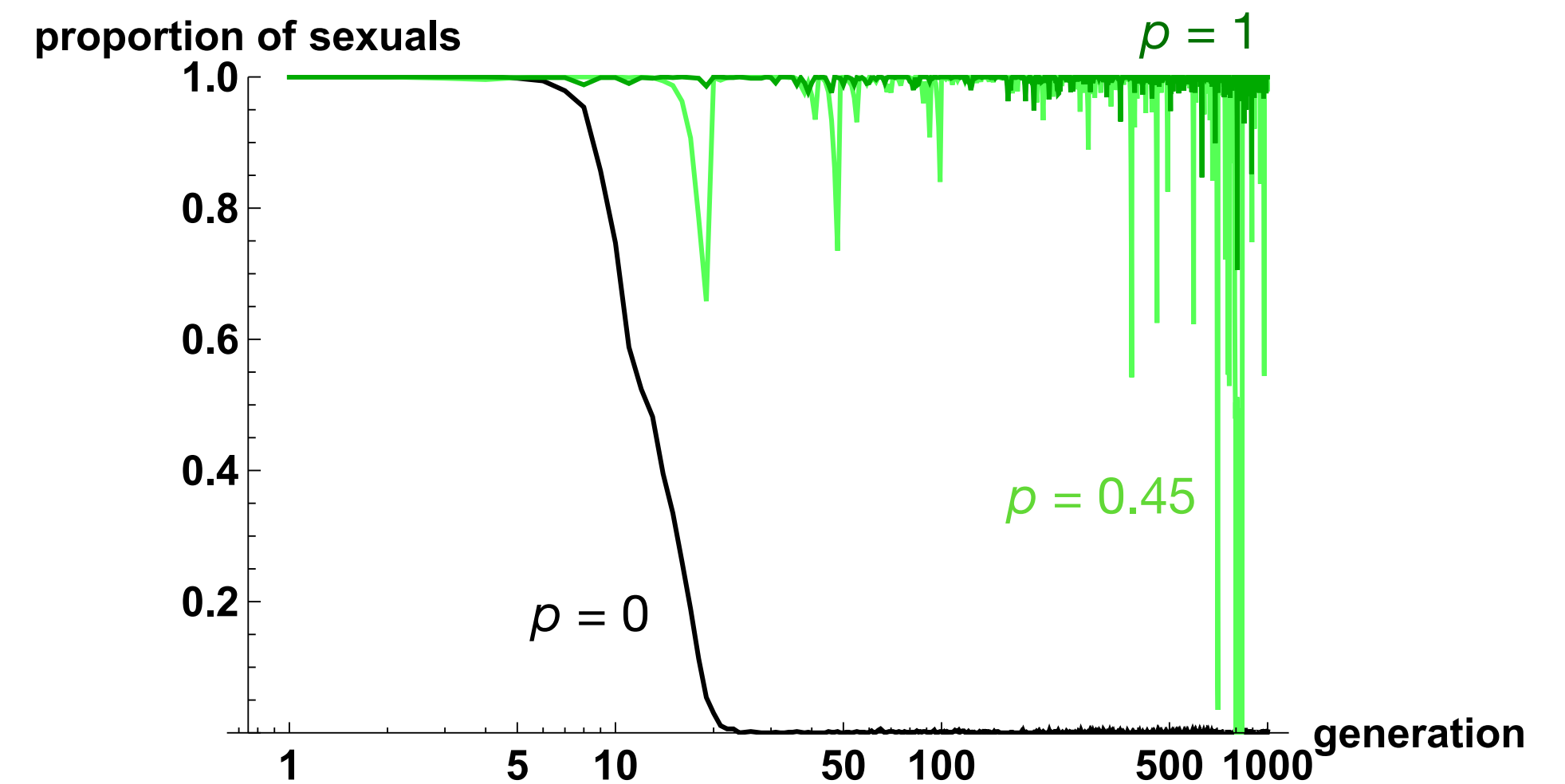
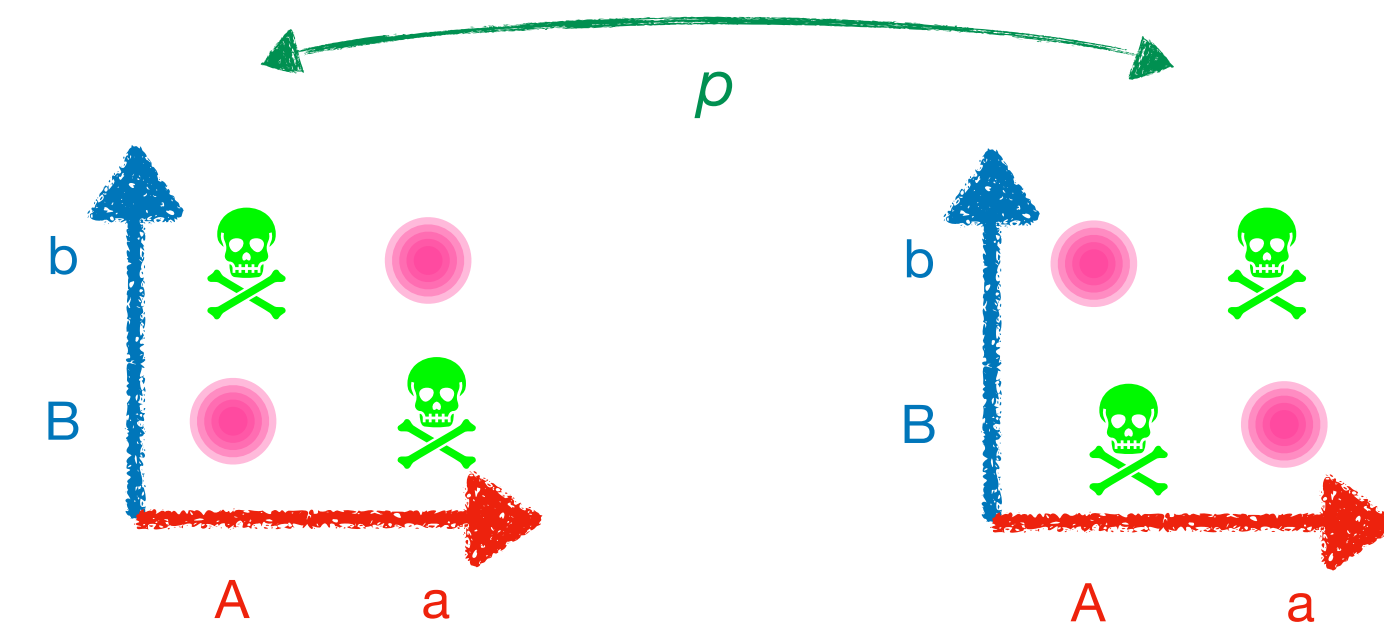
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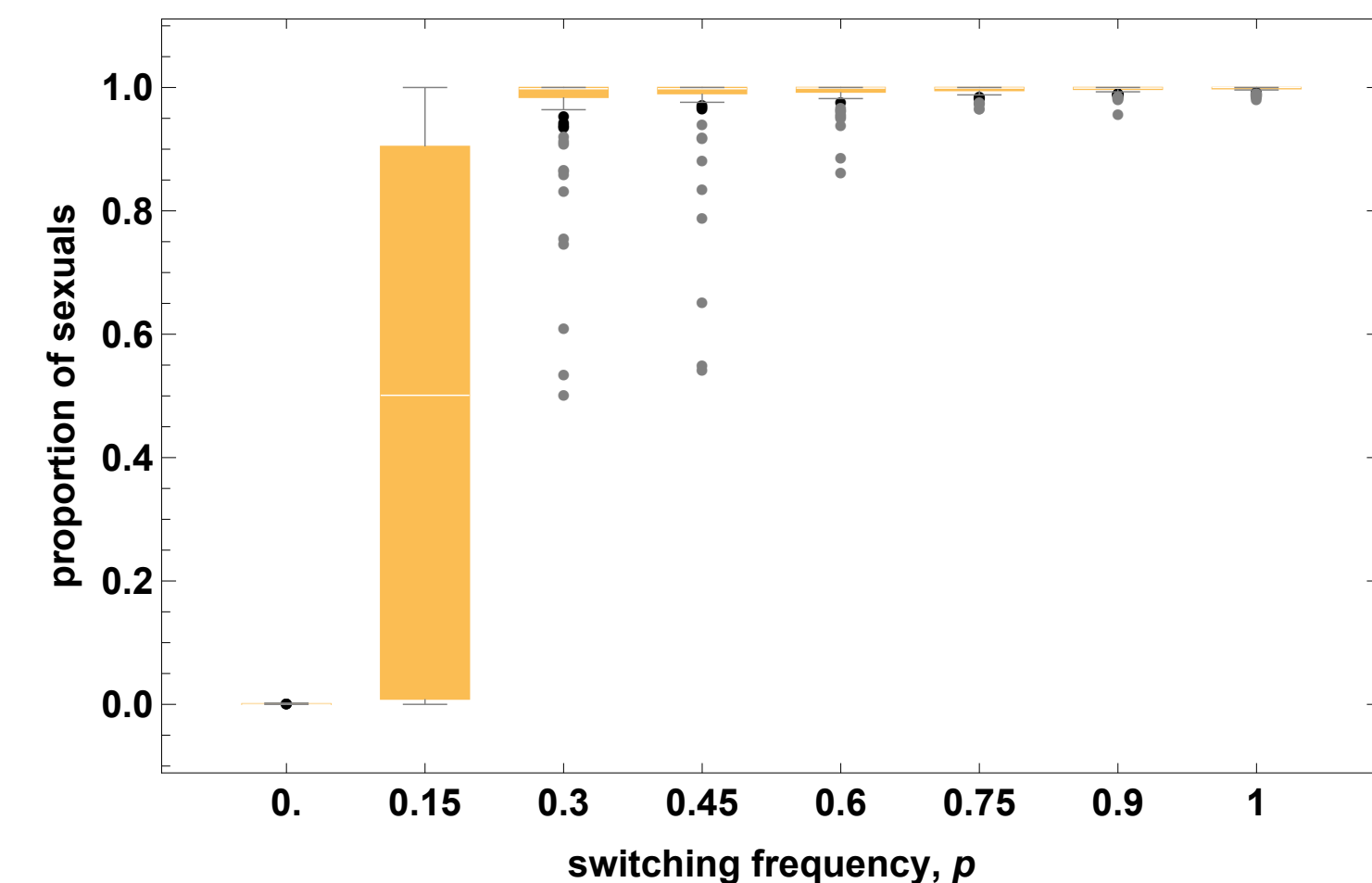
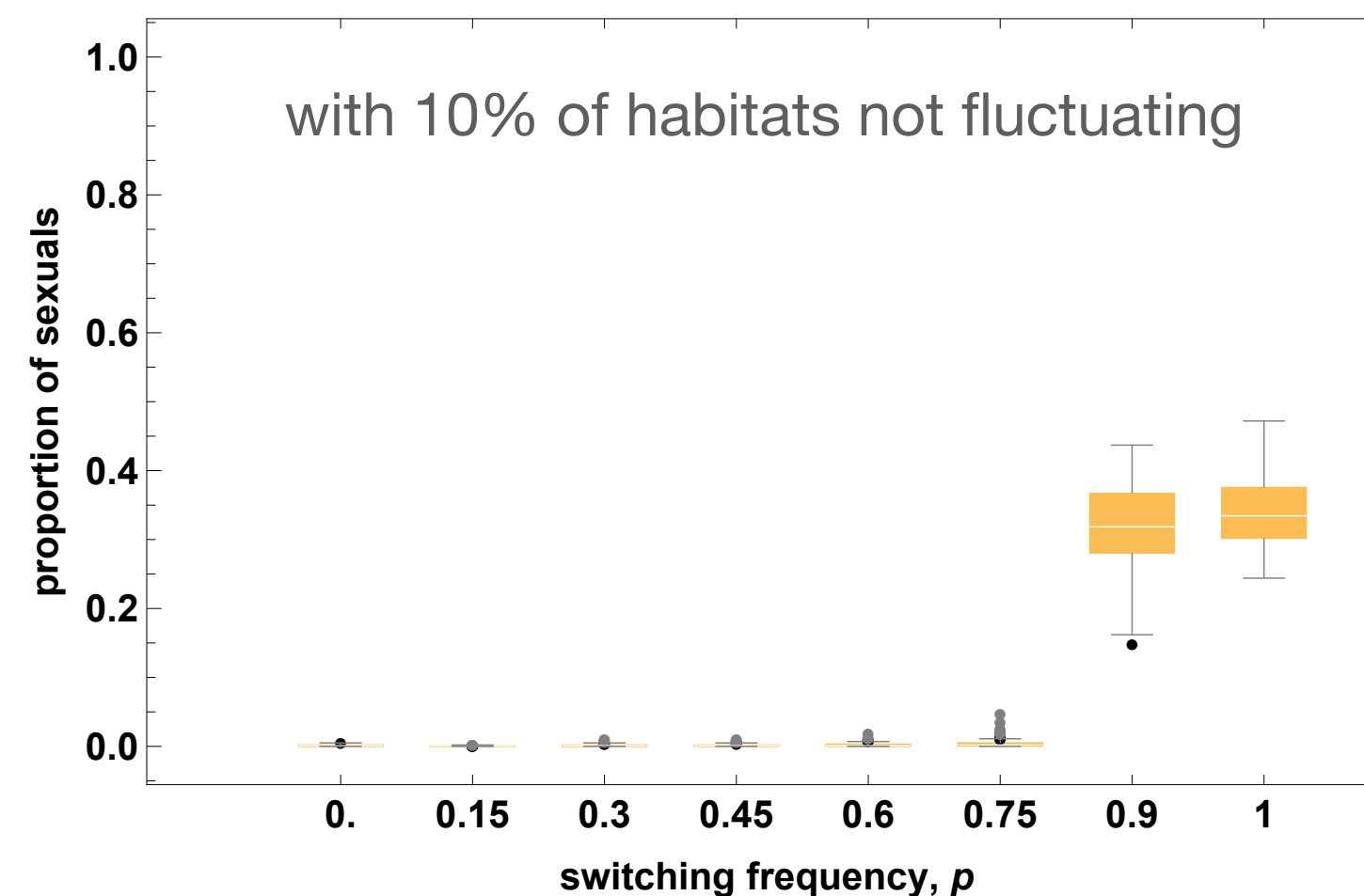
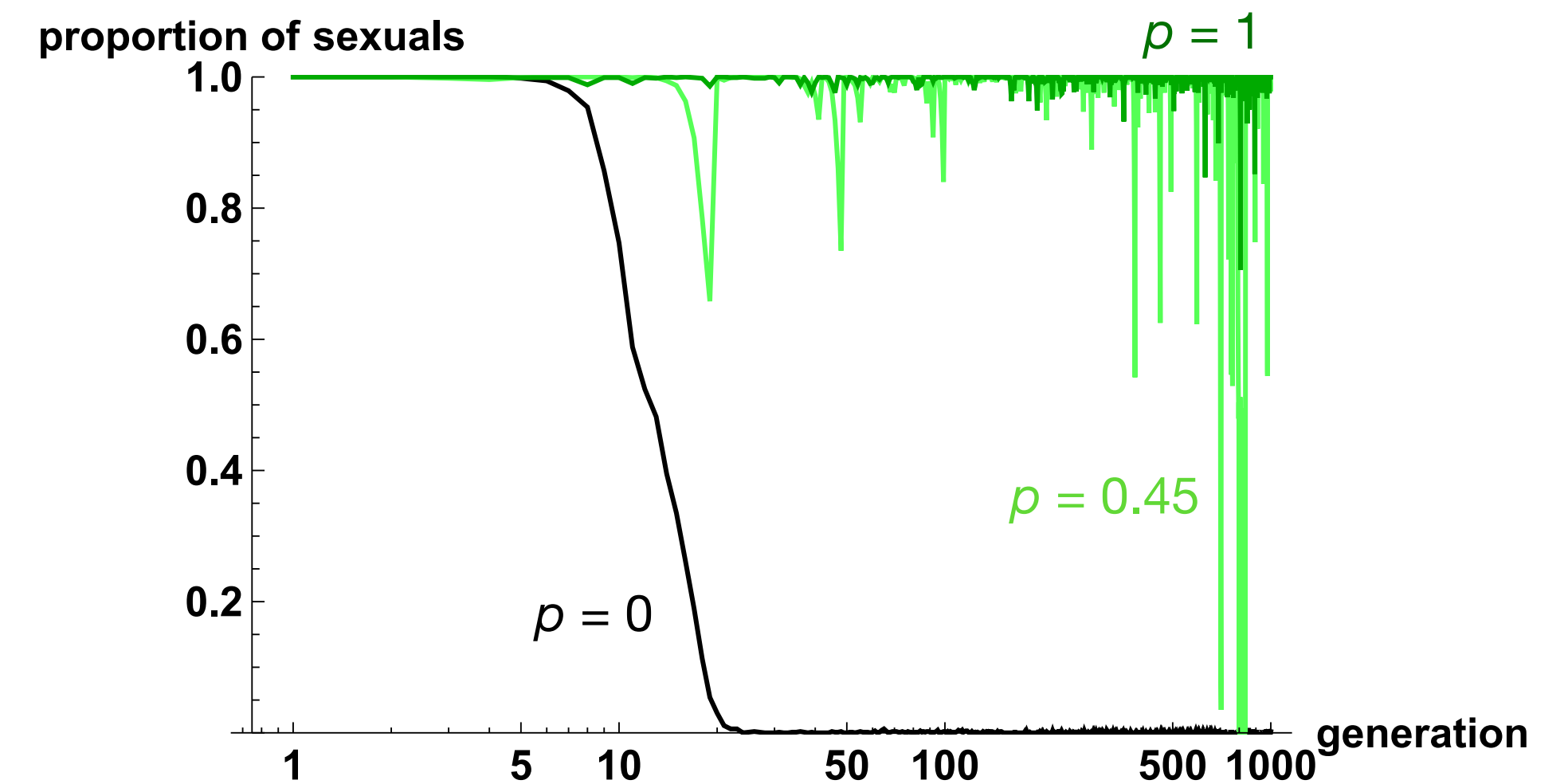
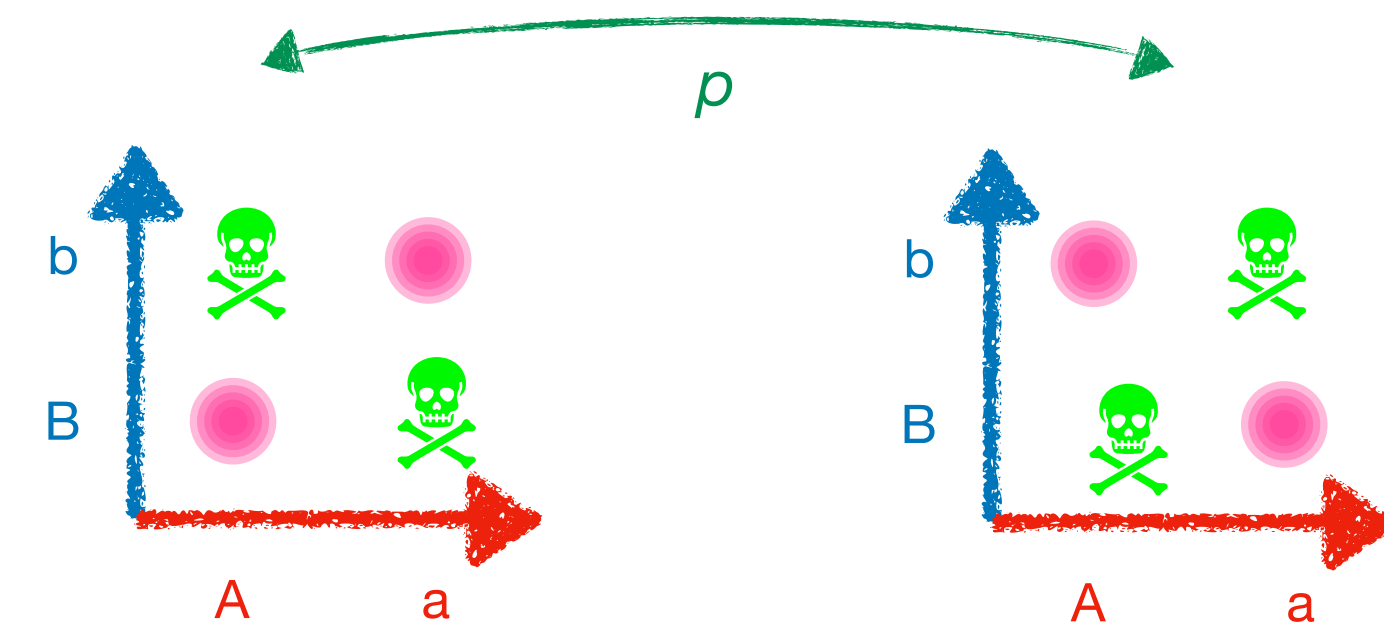
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# Fluctuating epistasis

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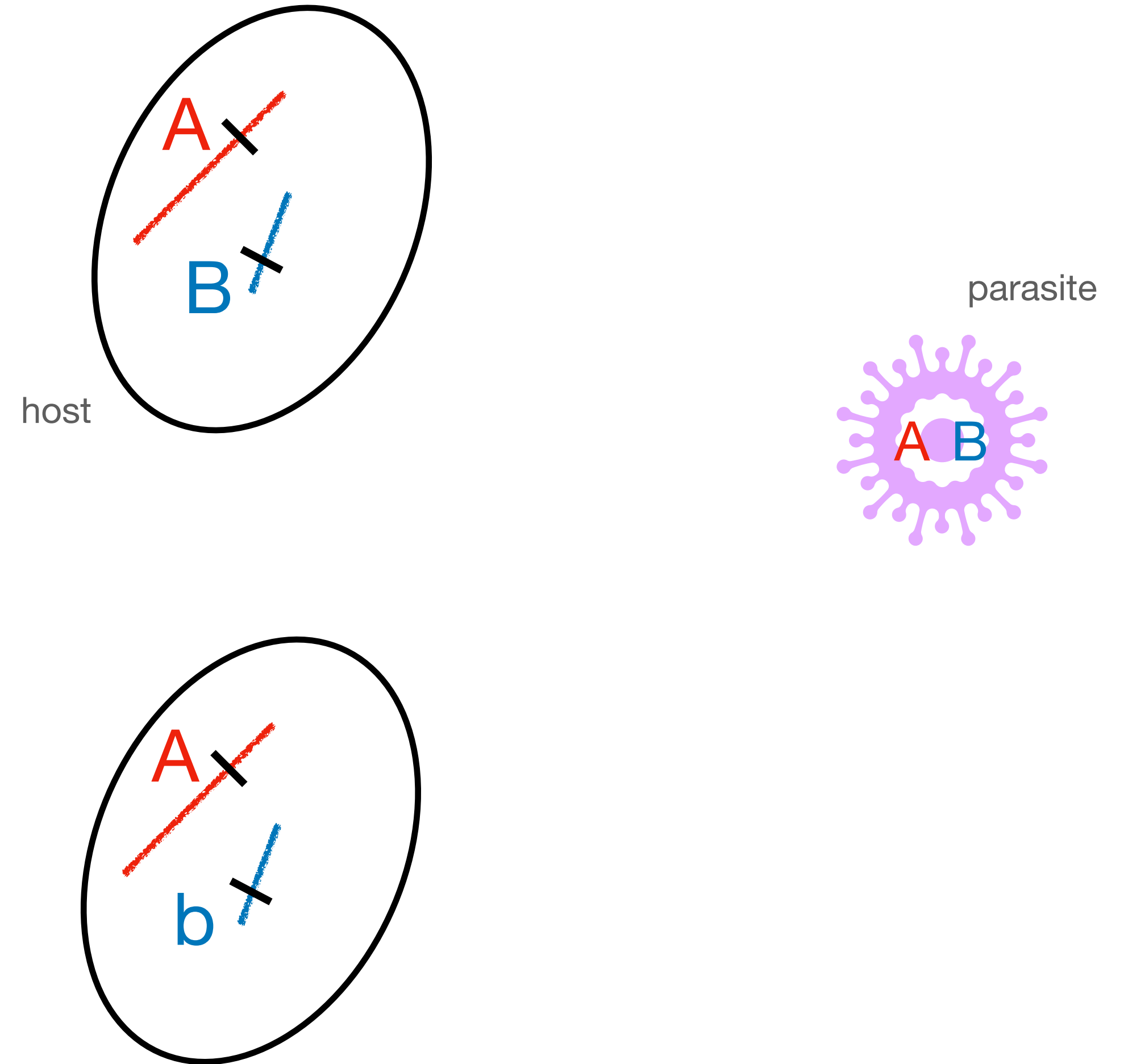
- Environmental and genetic assumptions seem unrealistic.
- Allowing for refugia makes it much more difficult to maintain sexual reproduction:



# **An ecological model of fluctuating epistasis**

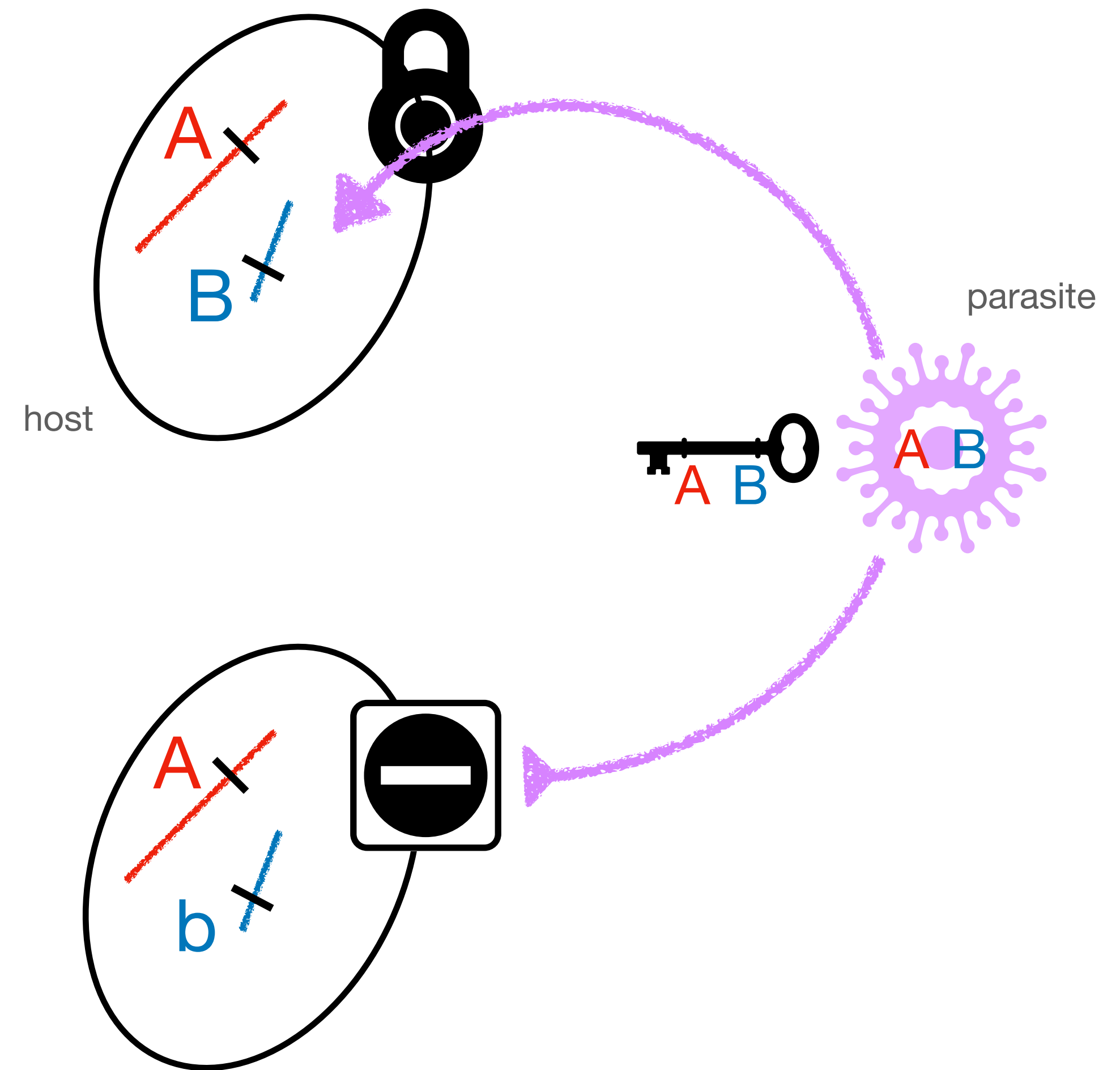
# An ecological model of fluctuating epistasis

- Coevolution of host and parasites.



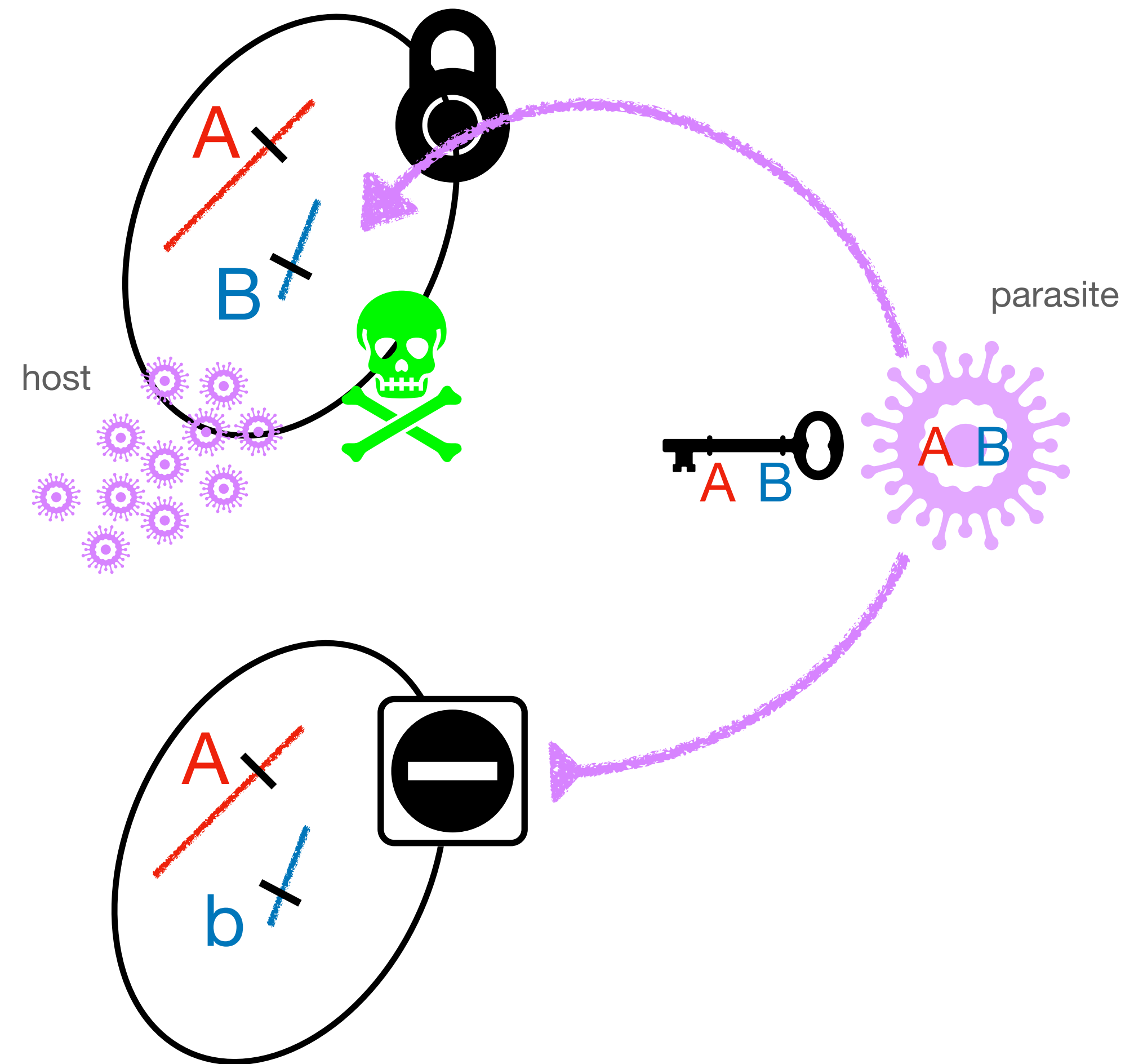
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- Coevolution of host and parasites.
- Lock and key system where parasites can only target host with matching genotype.



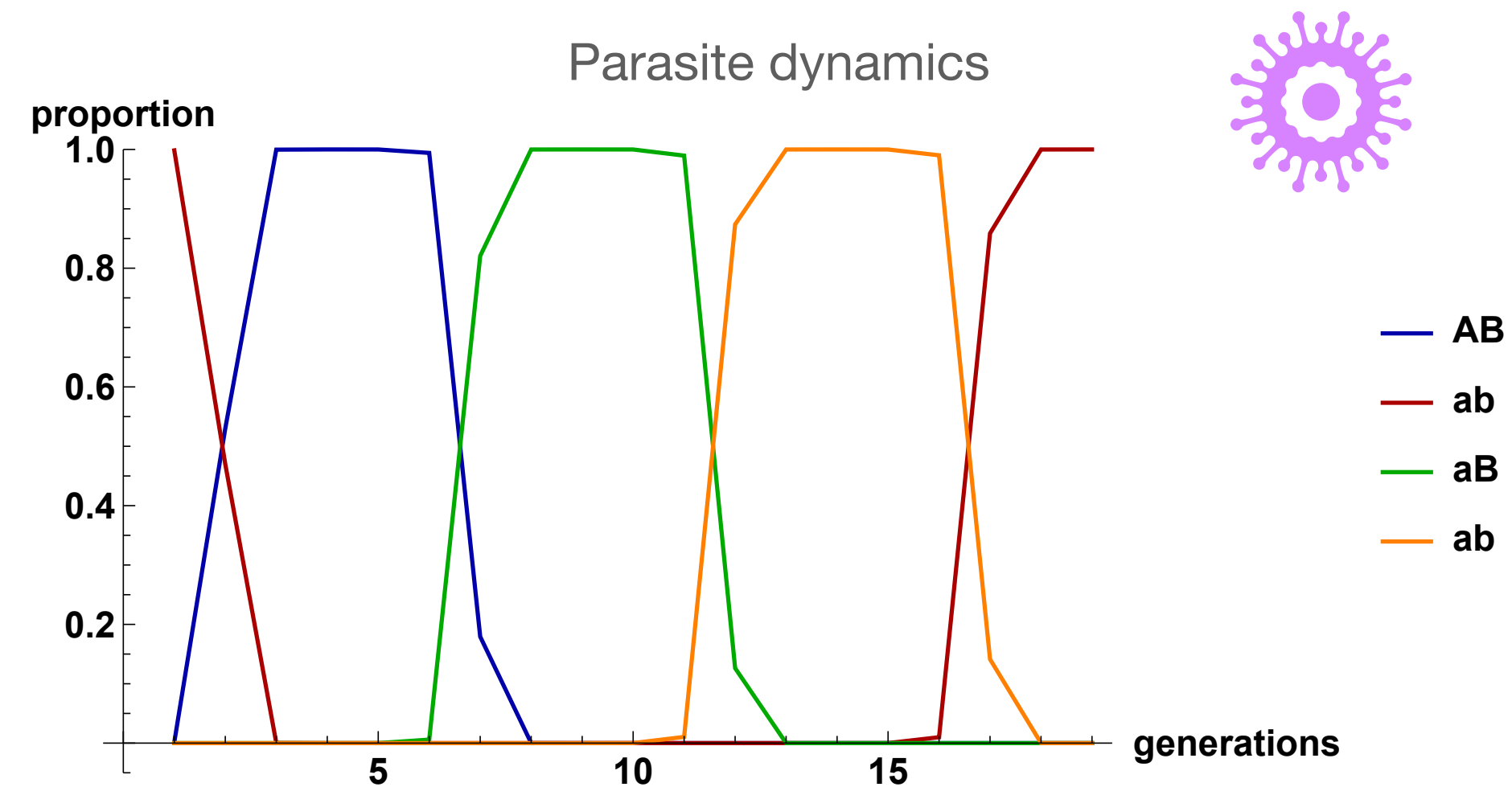
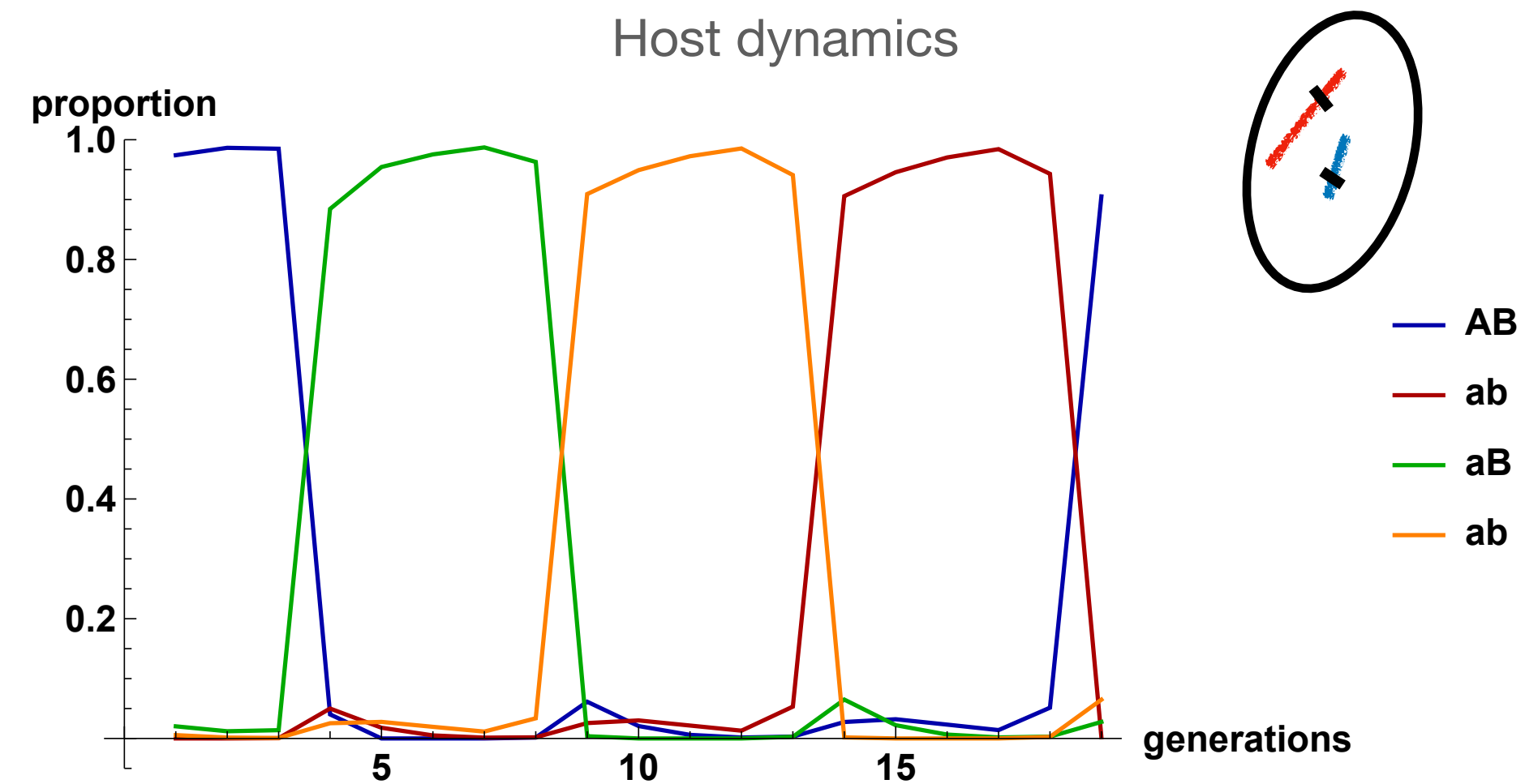
# An ecological model of fluctuating epistasis

- Coevolution of host and parasites.
- Lock and key system where parasites can only target host with matching genotype.
- Selection on parasites to match dominant host, selection on host to evade dominant parasite.
- Creates fluctuating epistasis in host.



# An ecological model of fluctuating epistasis

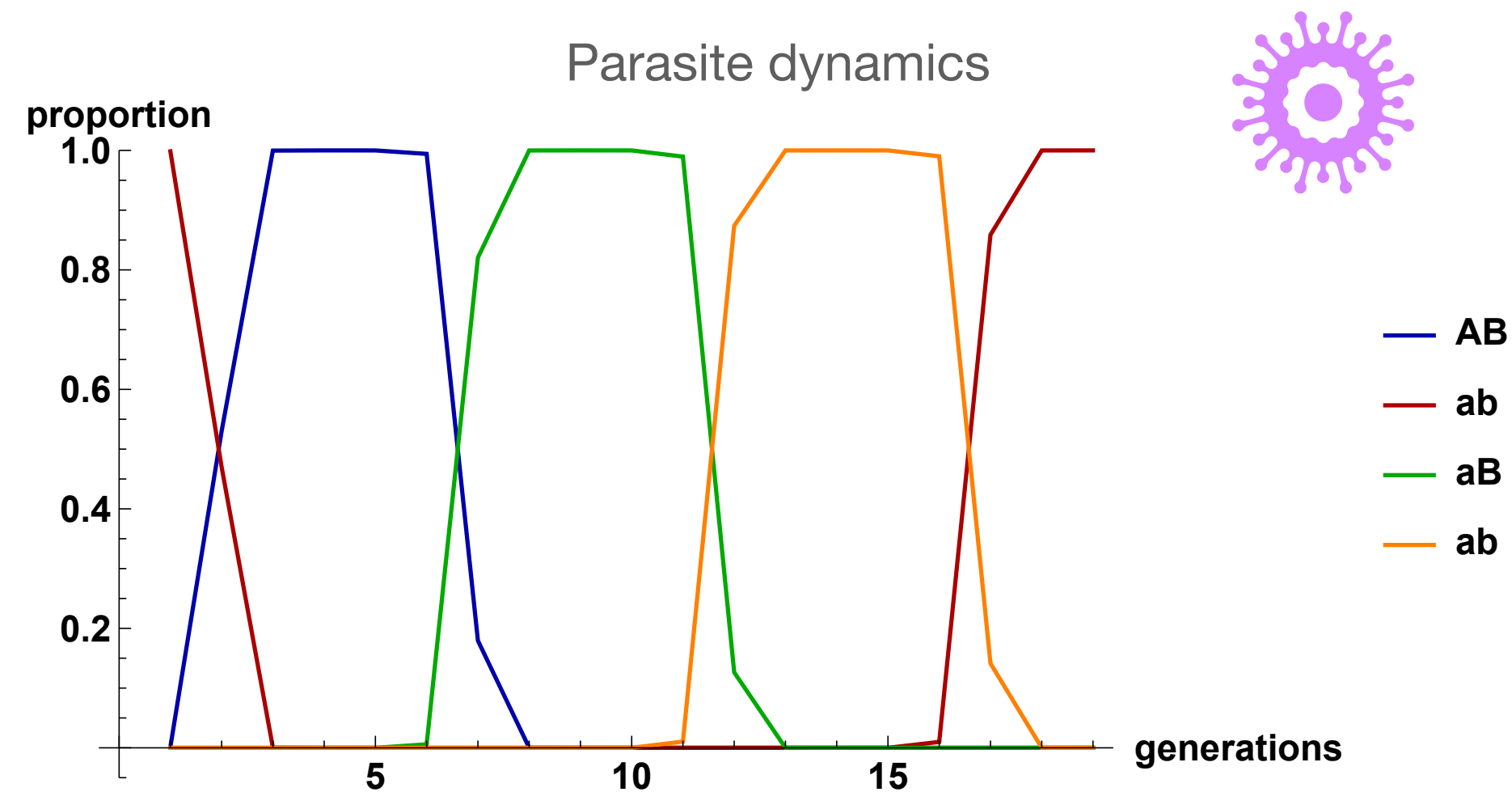
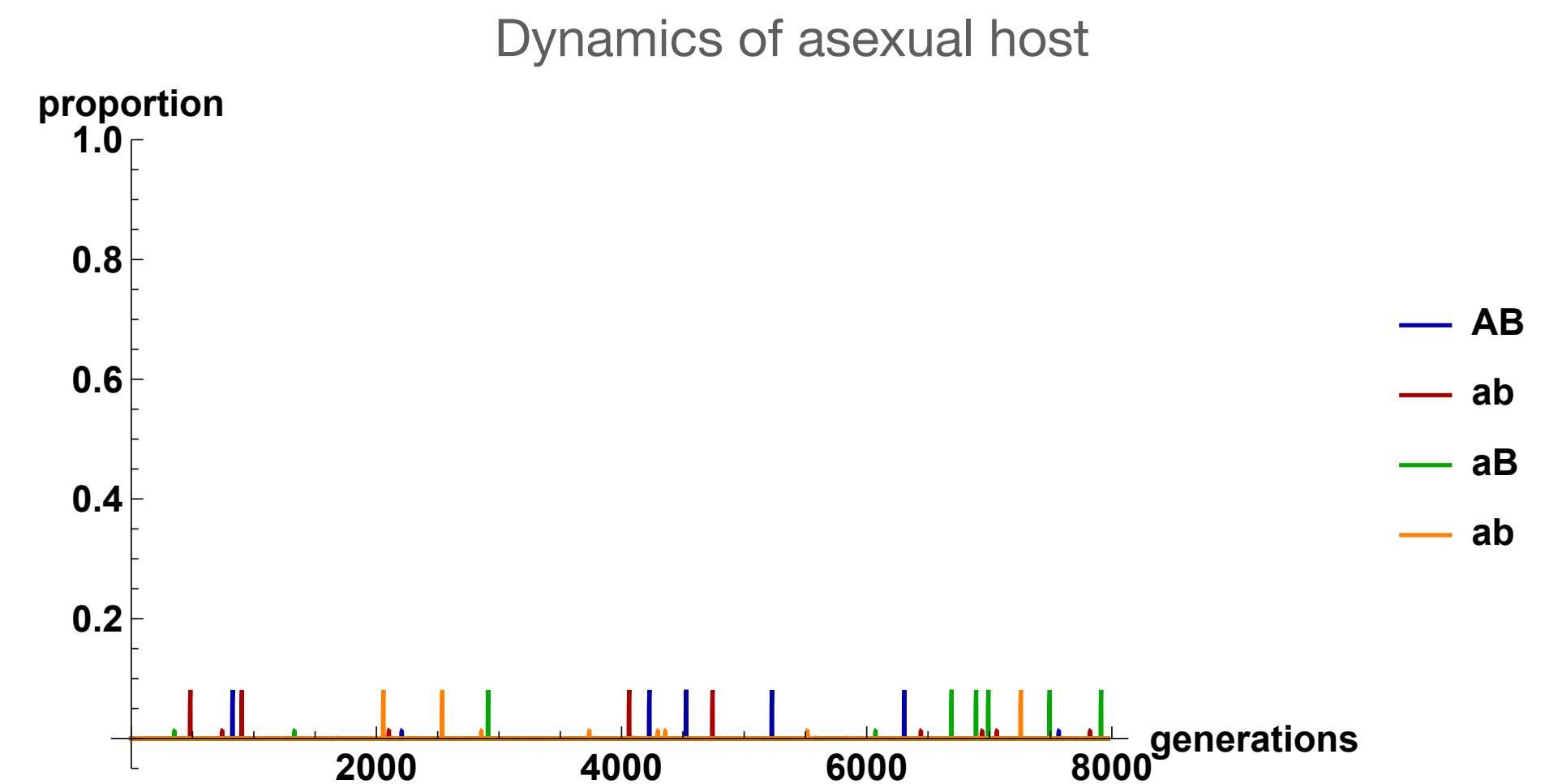
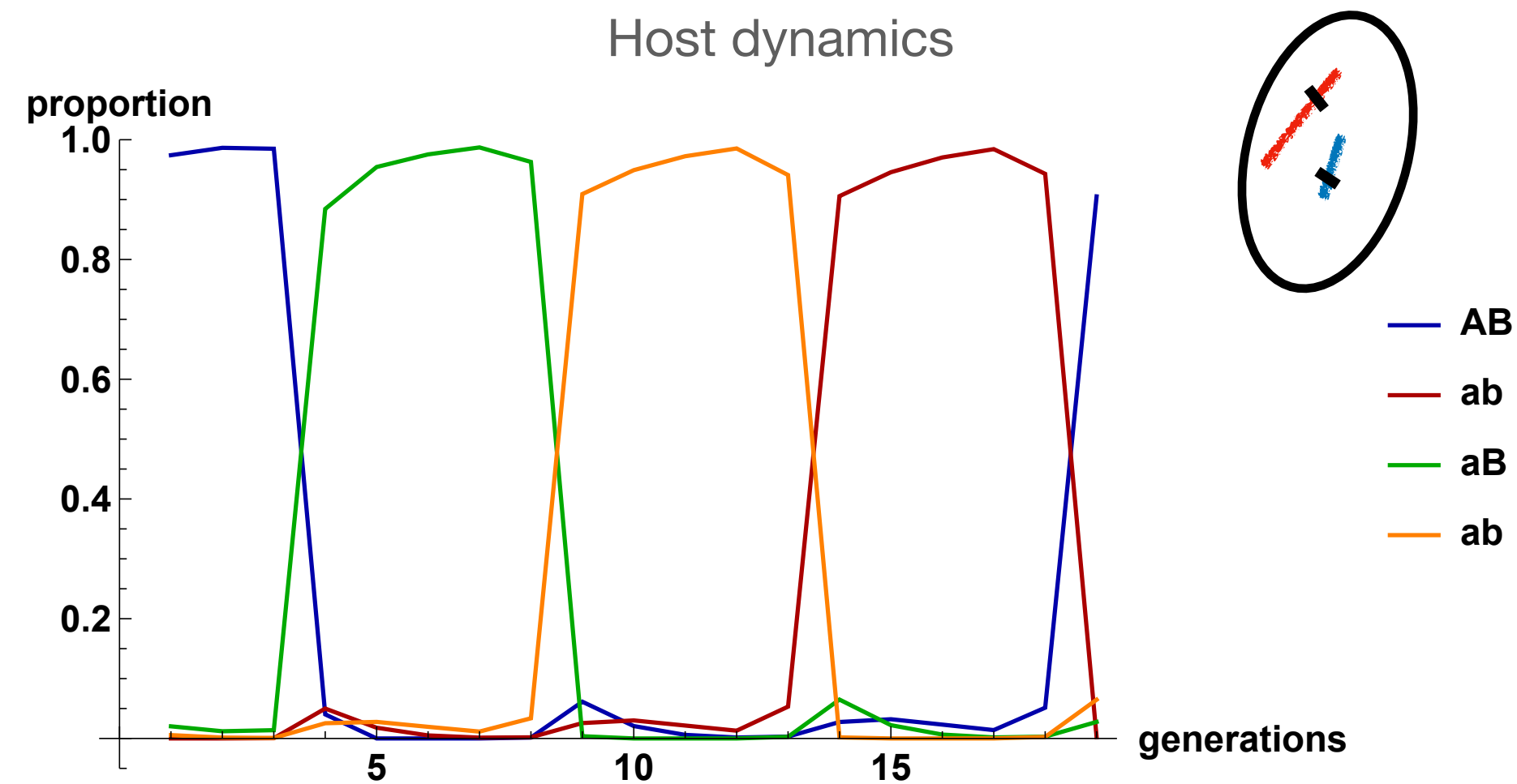
## Red queen dynamics





# An ecological model of fluctuating epistasis

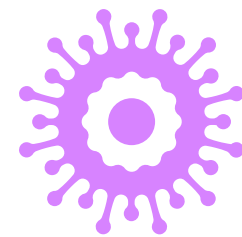
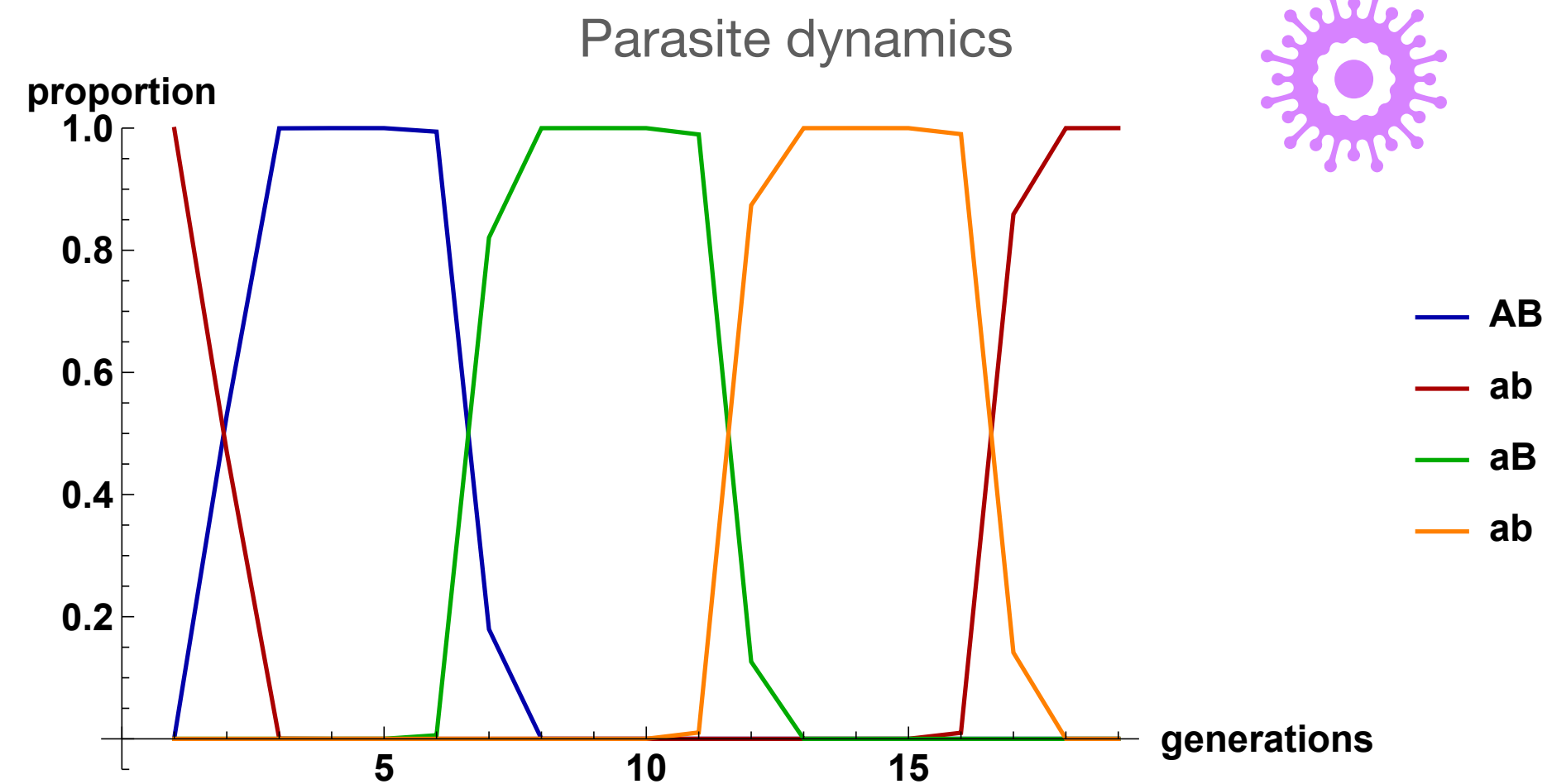
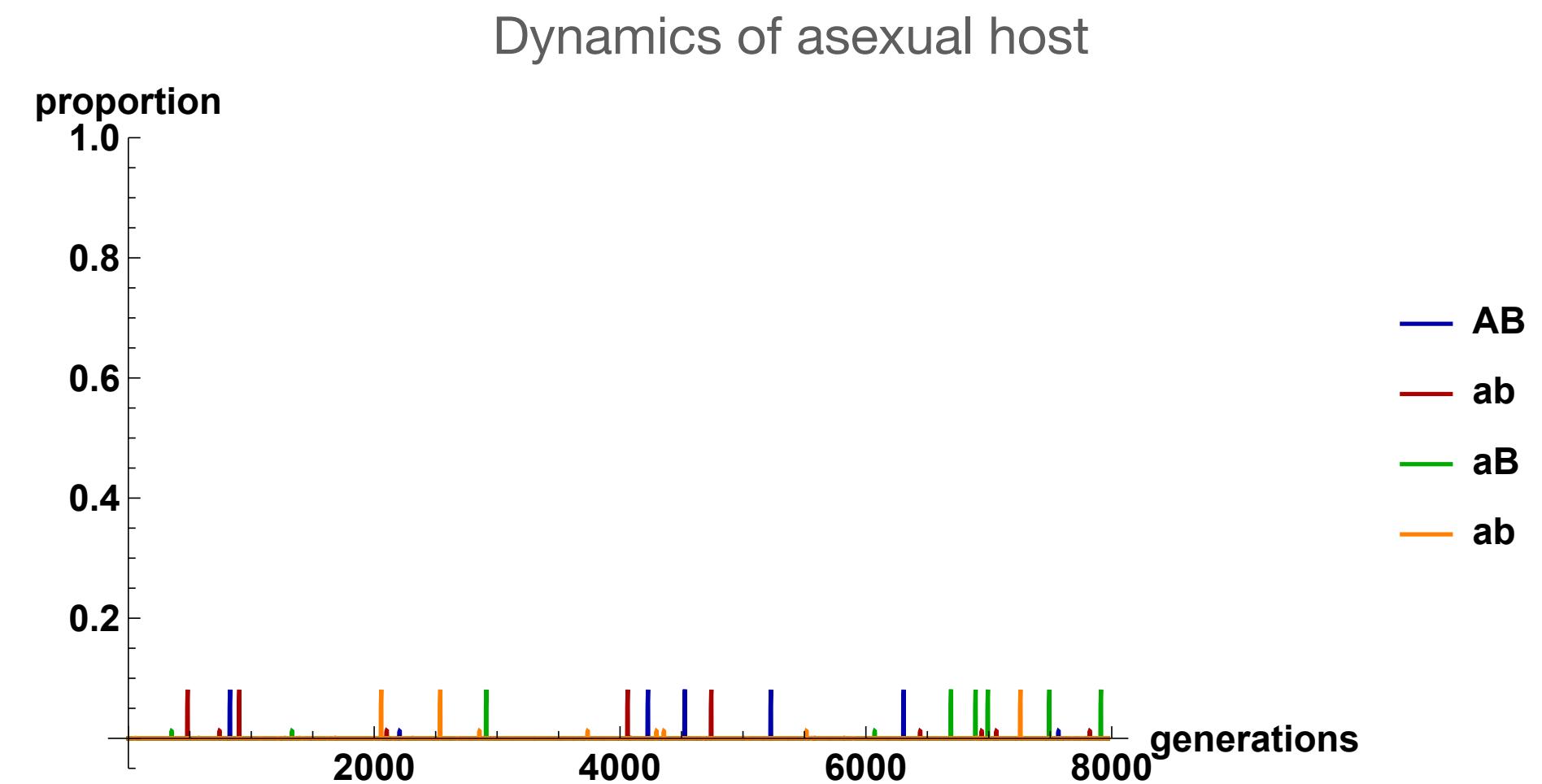
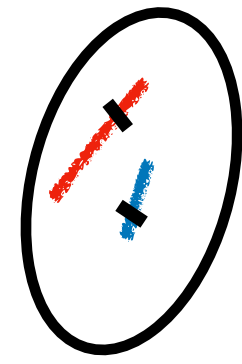
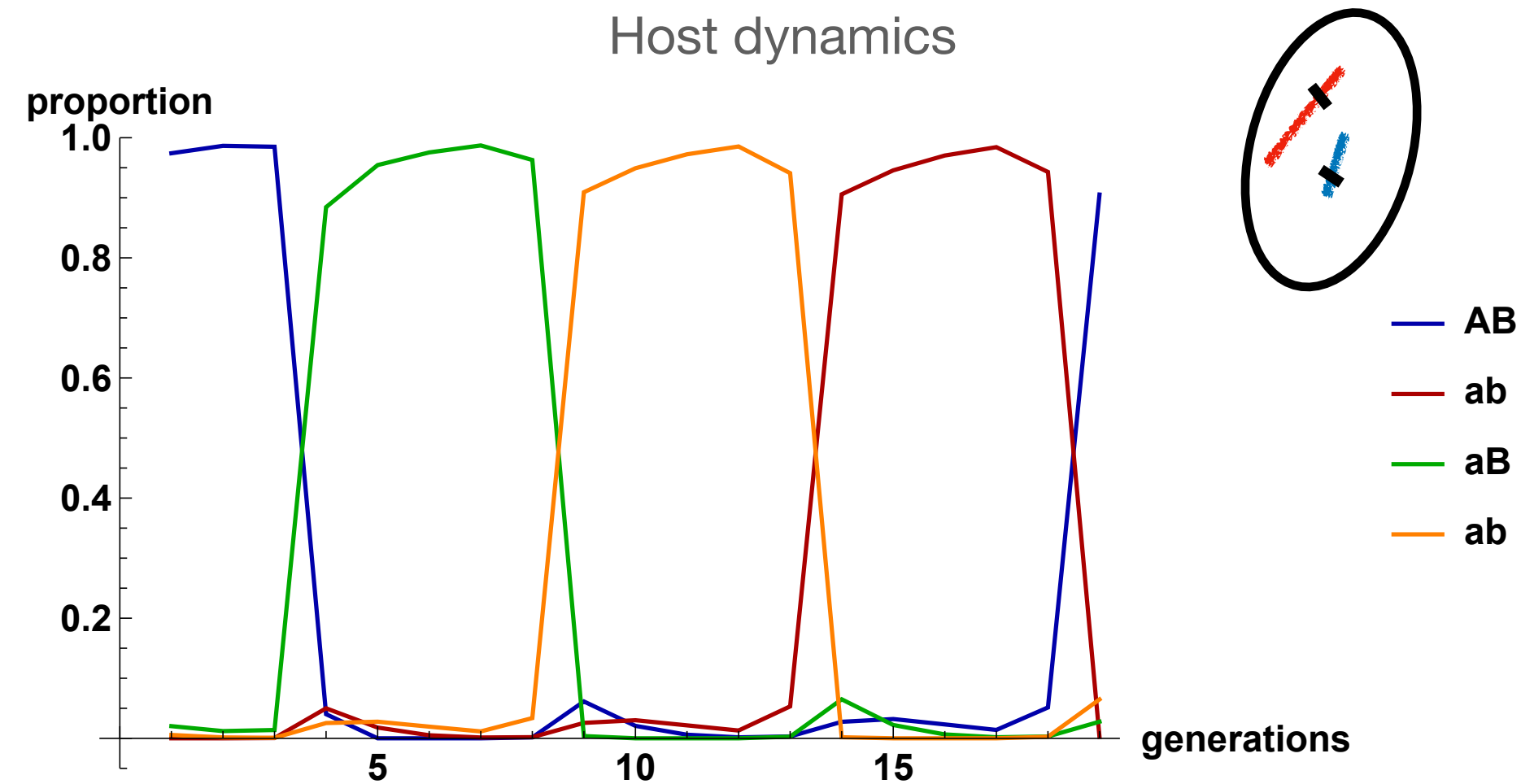
## Red queen dynamics



Red queen dynamics can trigger fluctuating epistasis, favouring sexual reproduction.

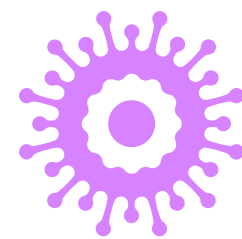
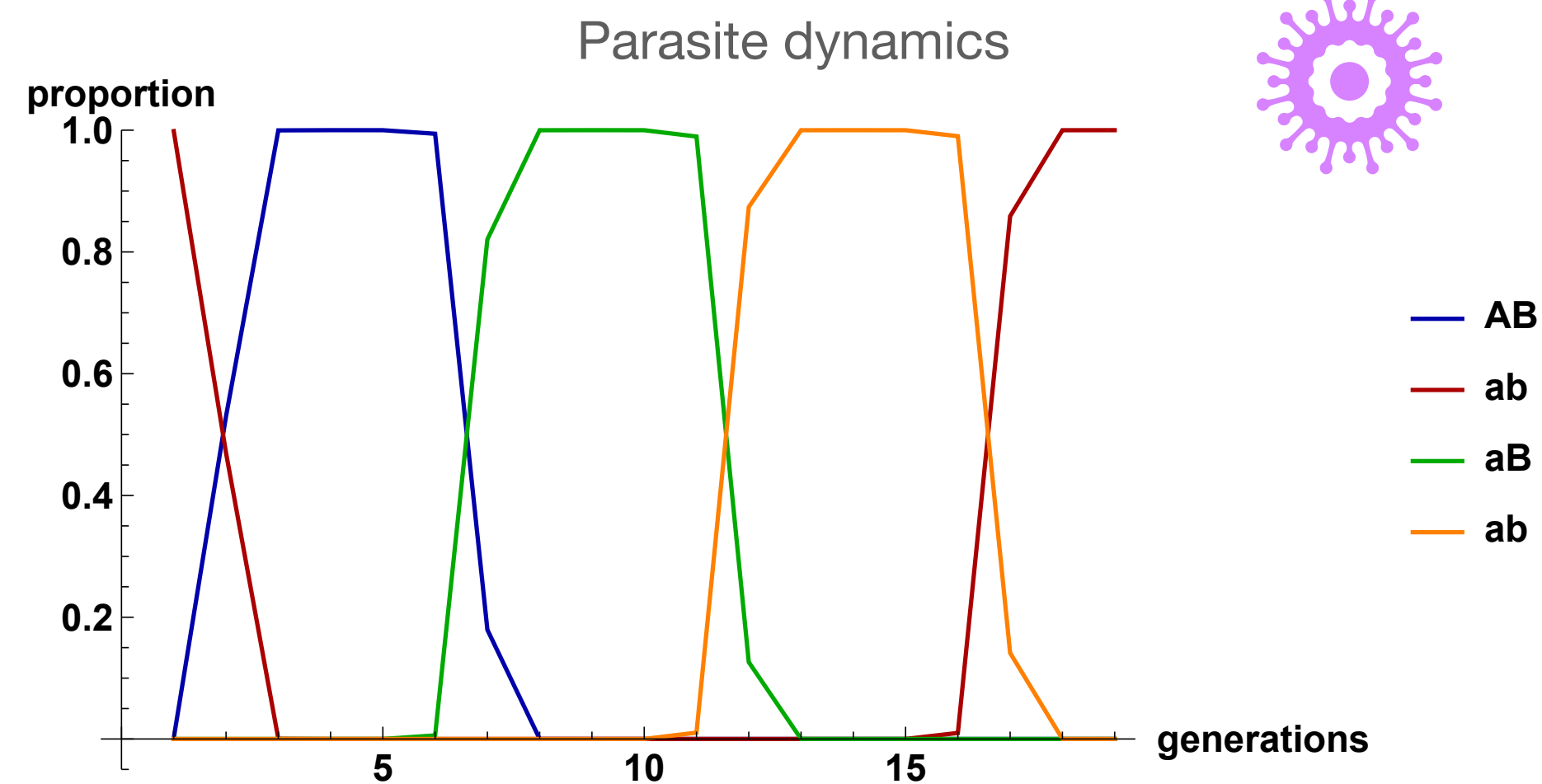
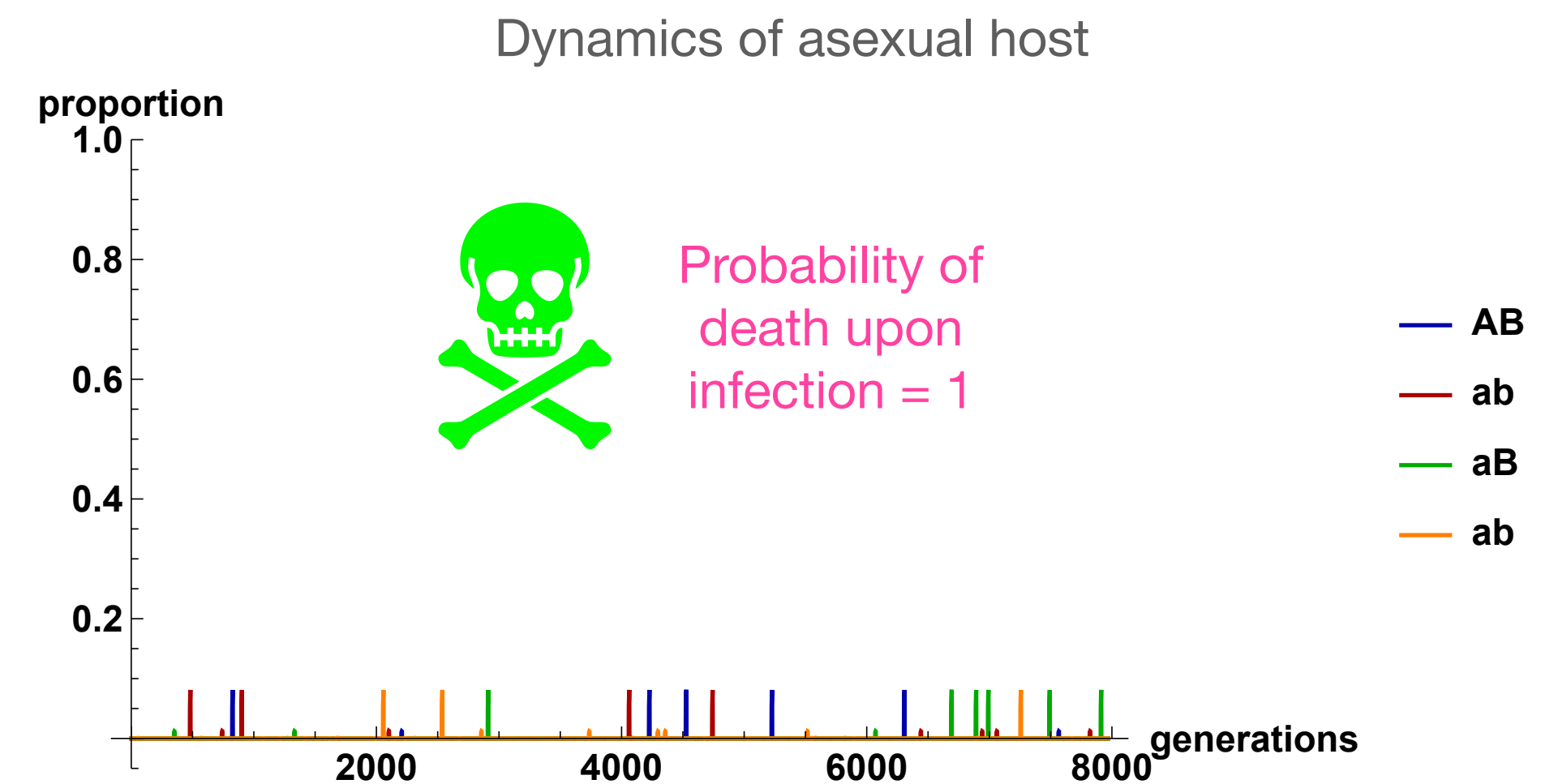
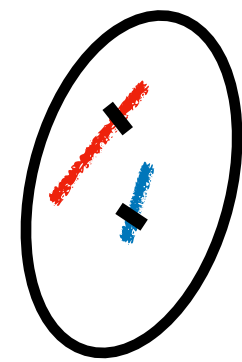
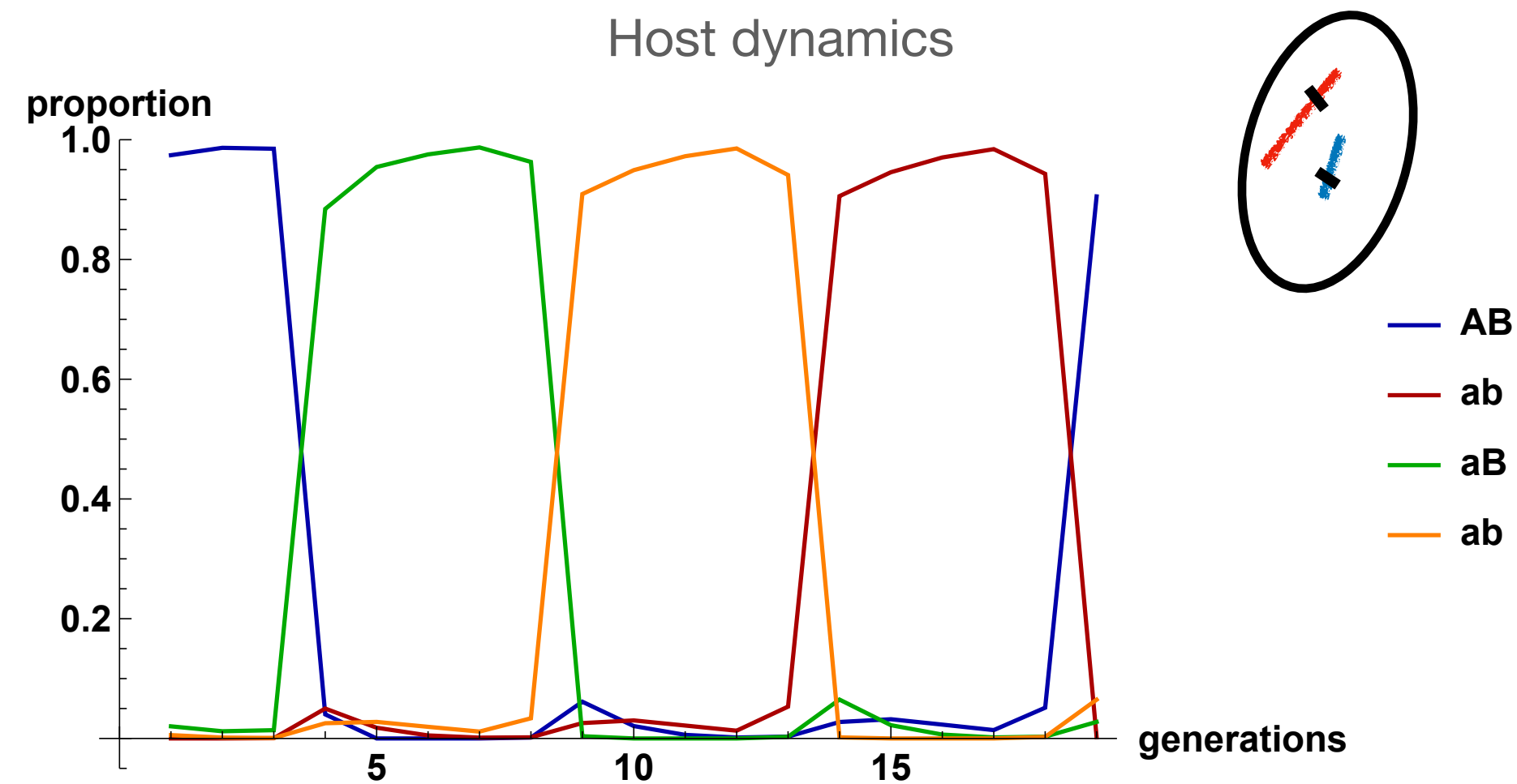
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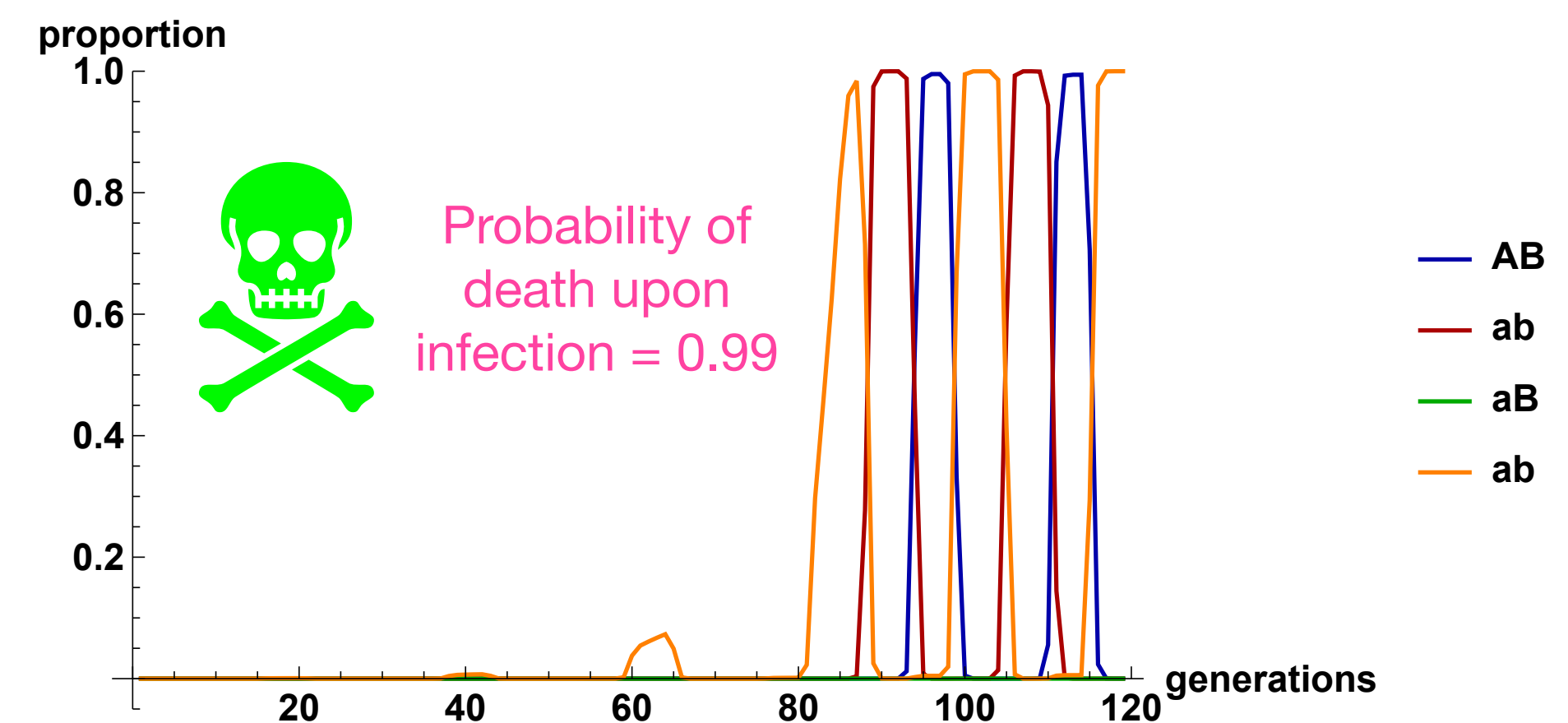
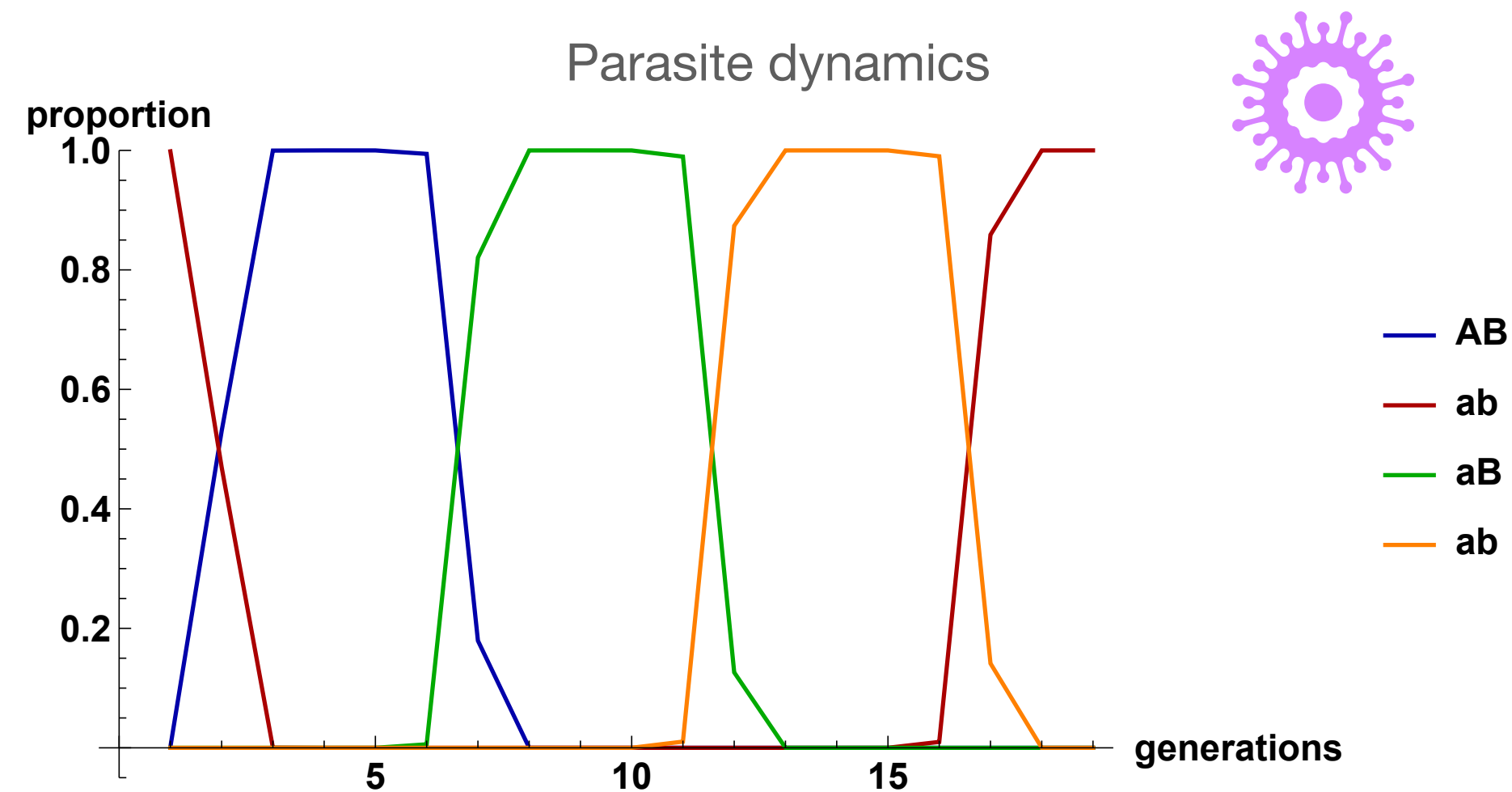
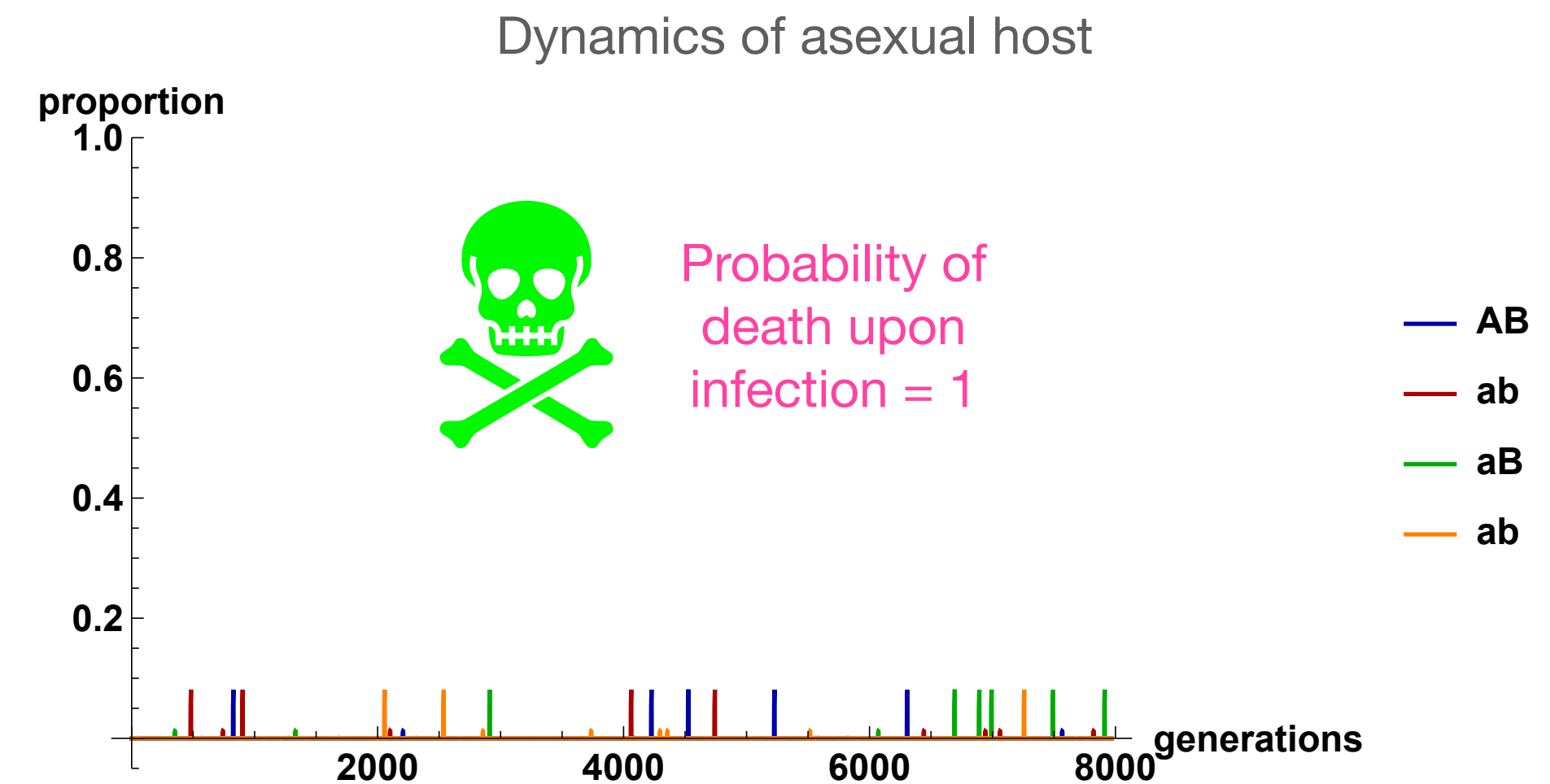
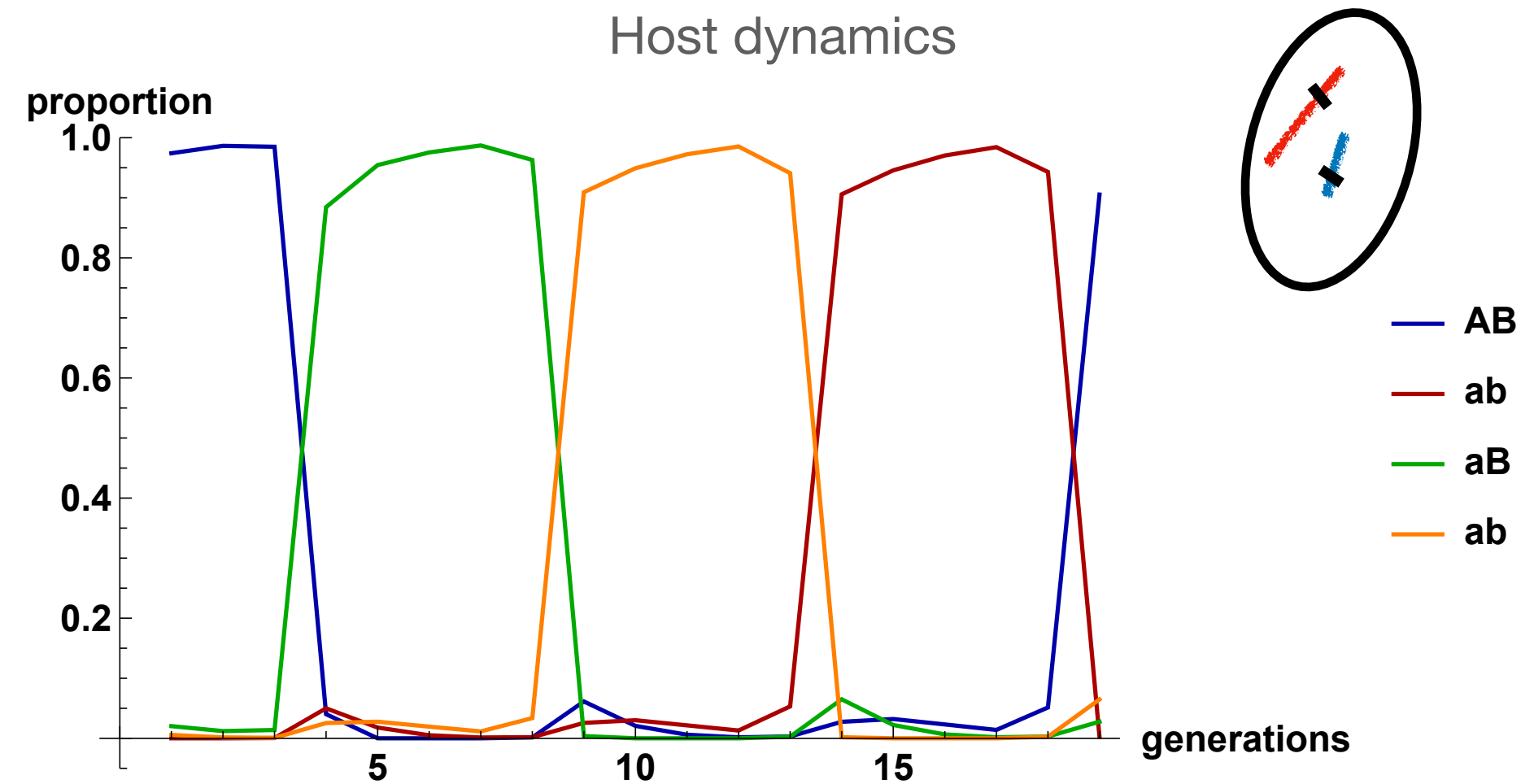
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# Summary

- Maintenance of sex is not straightforward: rapid demographic advantage versus slow evolutionary cost of asexuality.
- Strong epistasis can mitigate demographic advantage as fitness decreases rapidly with new mutations.
- Fluctuating epistasis also disadvantages asexuals who cannot easily create novel allelic combinations.
- Ecological interactions can lead to red queen dynamics and fluctuating epistasis, favouring sexual reproduction.
- But existing models do not fully answer the question.

