

# Evolution: Theory of chance and change

Andrew Rominger

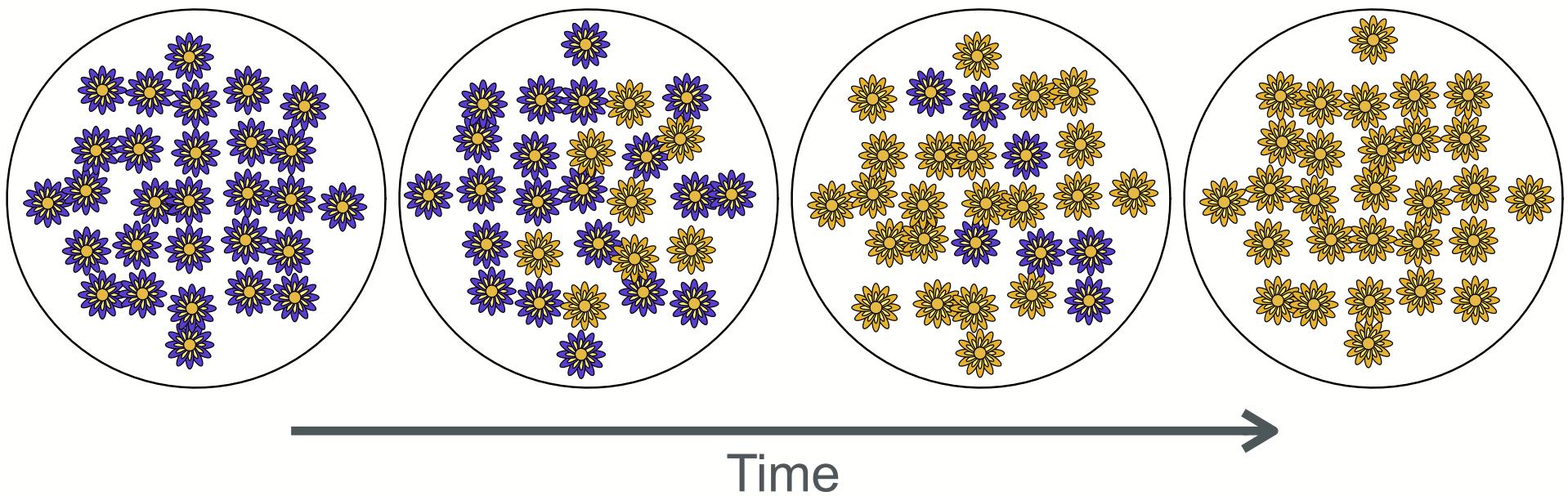
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# Evolution:

Change in the heritable characteristics of a population through time



# Evolution:

4 key processes

# Evolution:

- |                 |   |
|-----------------|---|
| 4 key processes | Perspectives on origins   |
|                 | <ul style="list-style-type: none"><li>• LUCA</li><li>• Complexity</li></ul> |

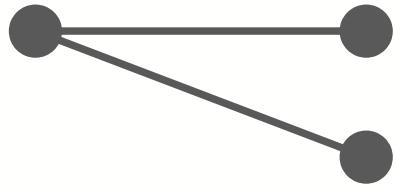
# Four key evolutionary processes

- Reproduction
- Mutation
- Drift
- Selection

# Reproduction (+ heritability)

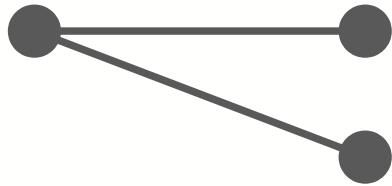


# Reproduction (+ heritability)



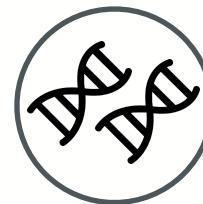
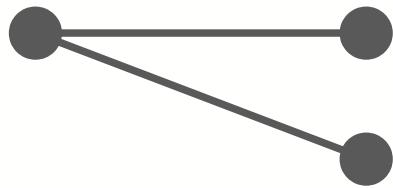
# Reproduction (+ heritability)

Offspring *internet* parent's traits



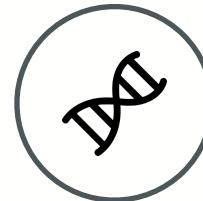
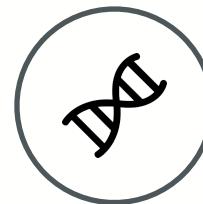
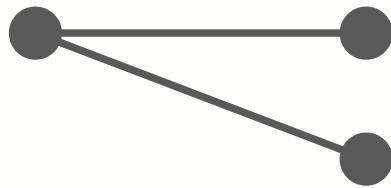
# Reproduction (+ heritability)

Allele considered separately  
(whether haploid or multiploid)

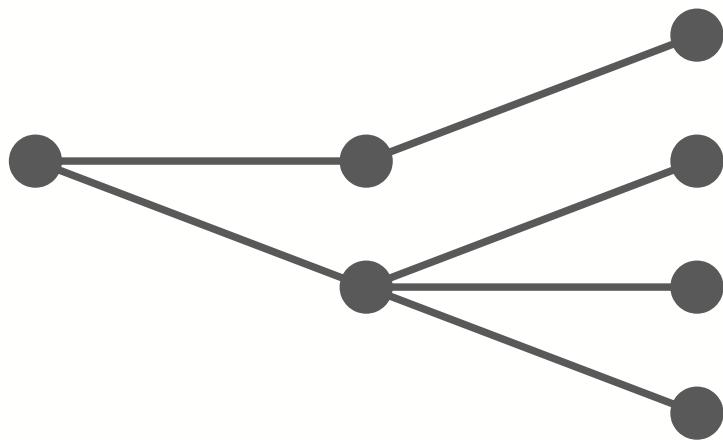


# Reproduction (+ heritability)

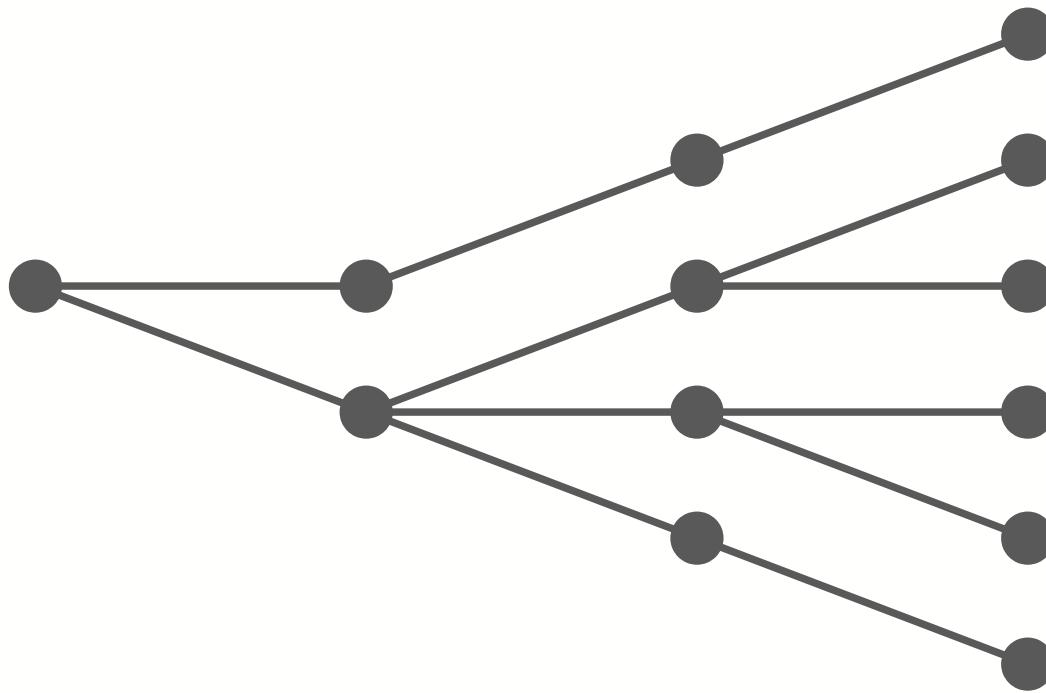
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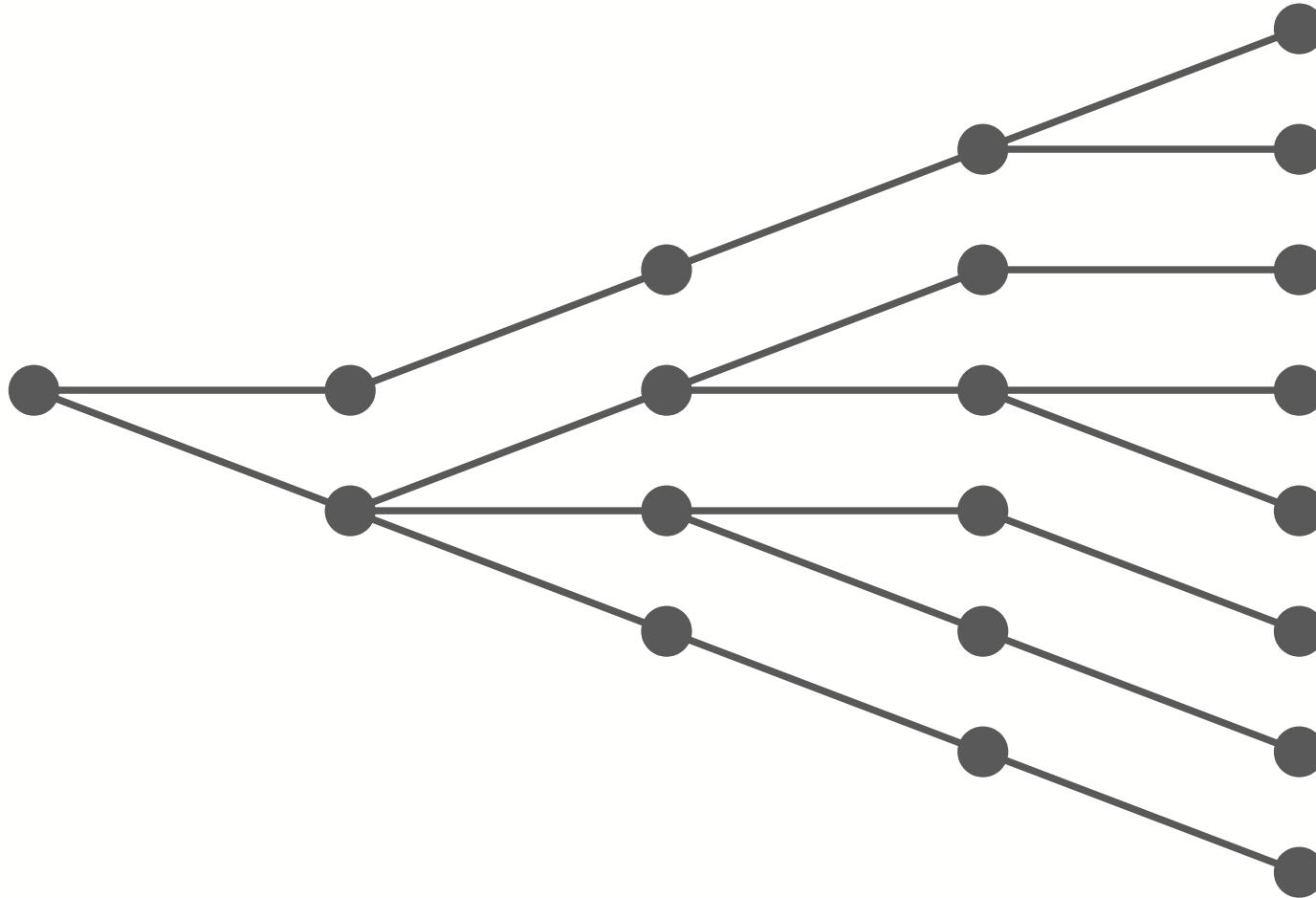
# Reproduction (+ heritability)



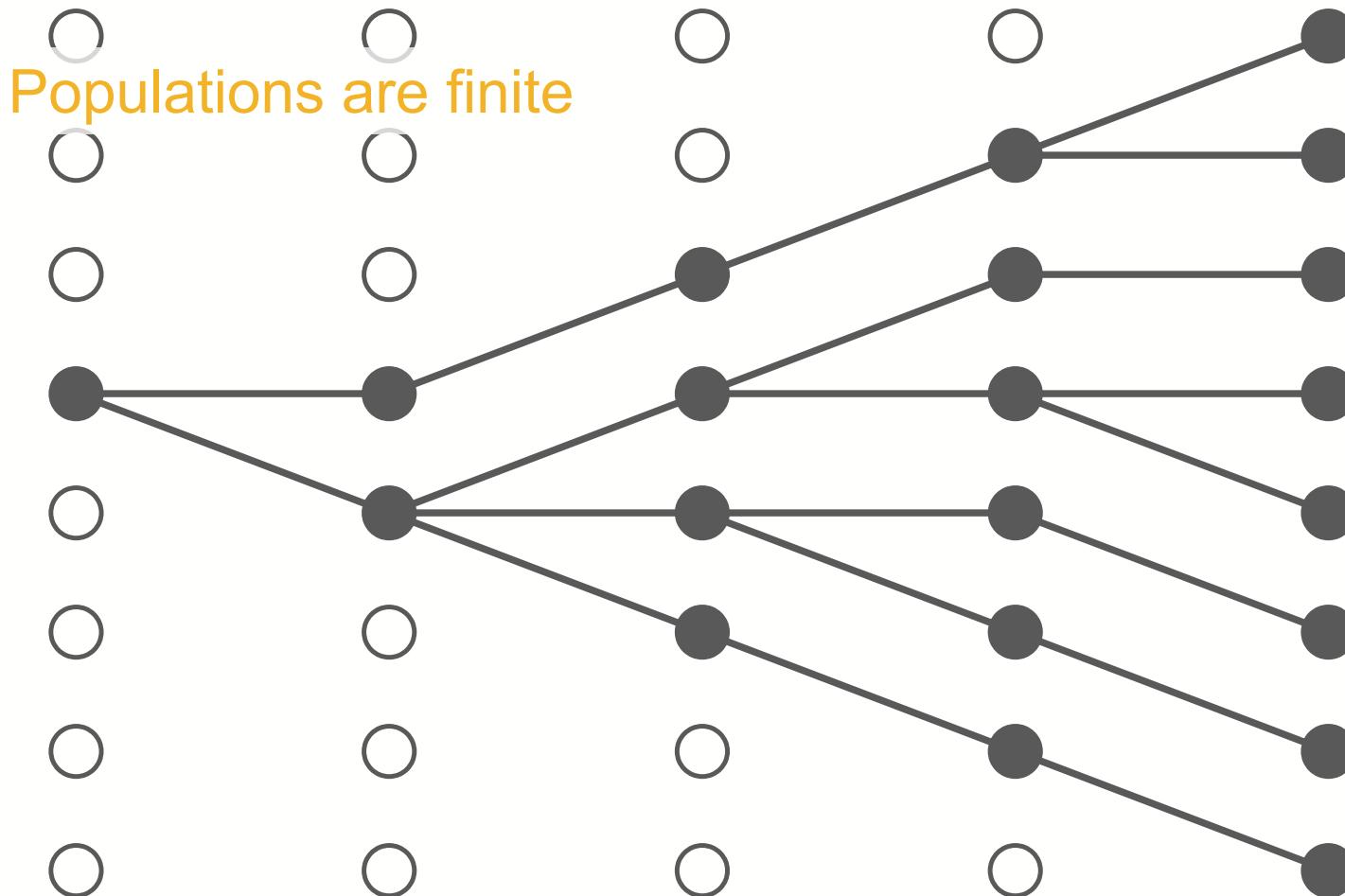
# Reproduction (+ heritability)



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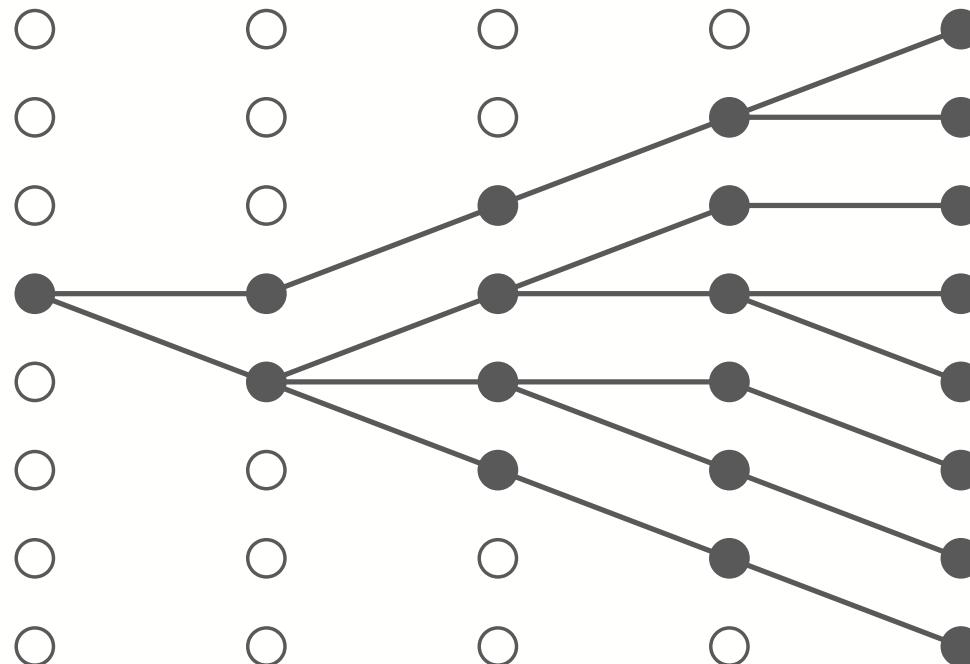
# Reproduction (+ heritability)



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Populations are finite

Coalescence

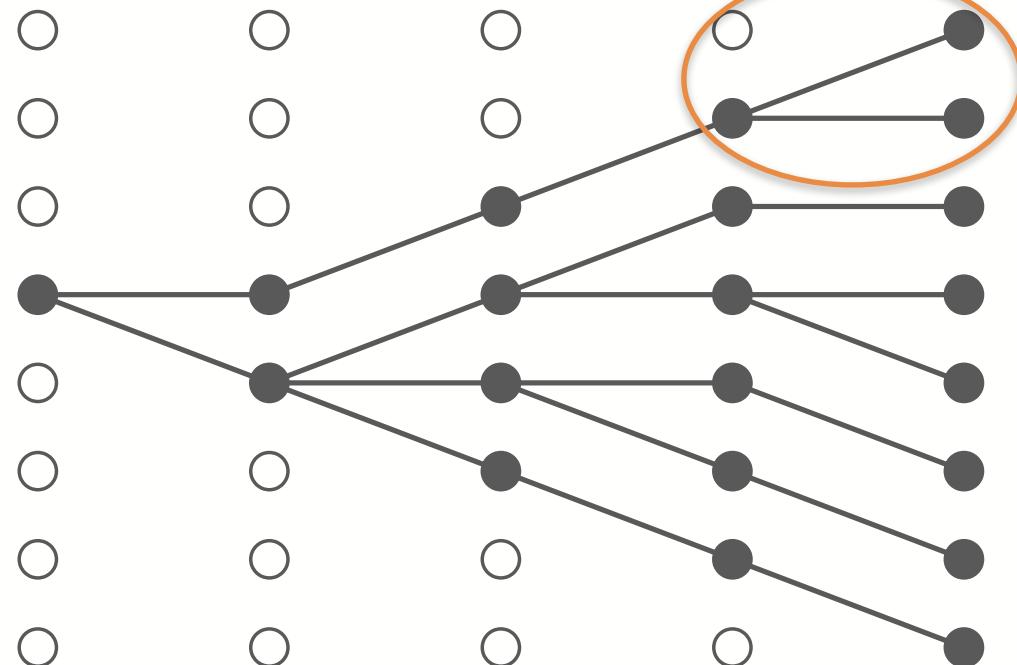


# Reproduction (+ heritability)

Populations are finite

Coalescence

$$\frac{1}{N}$$

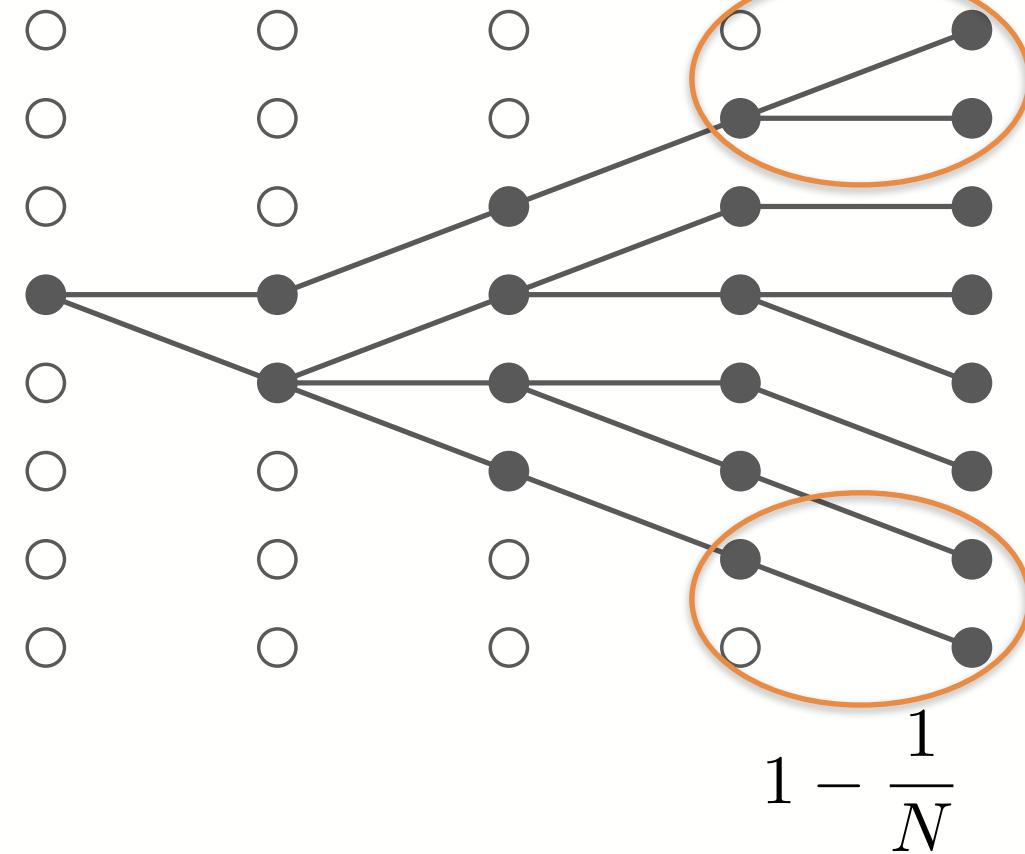


# Reproduction (+ heritability)

Populations are finite

Coalescence

$$\frac{1}{N}$$



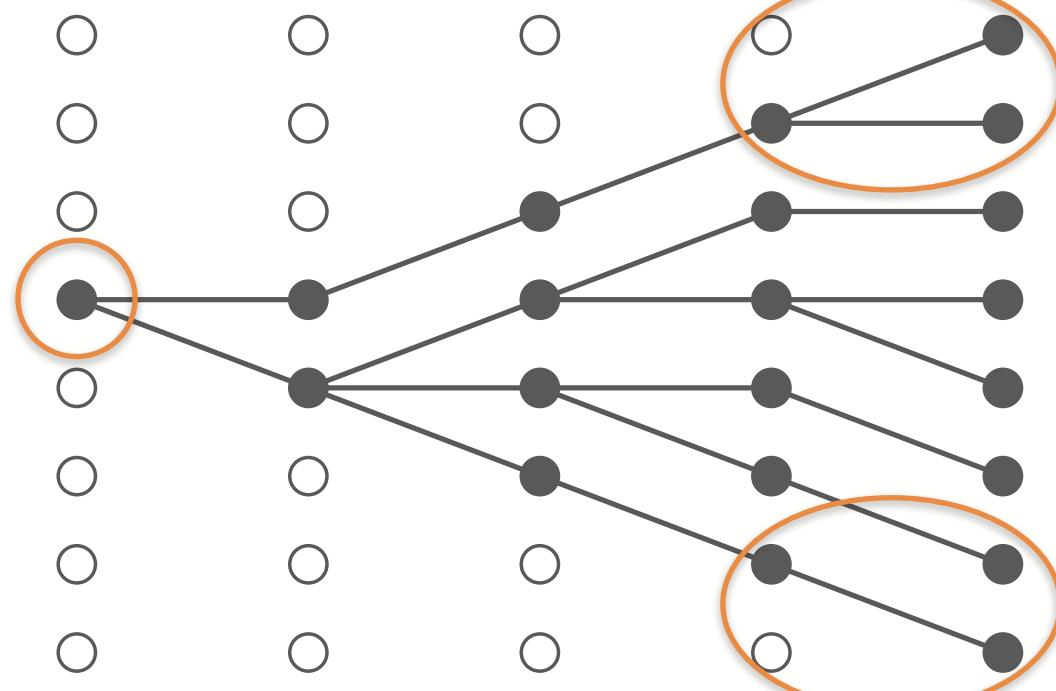
# Reproduction (+ heritability)

Populations are finite

Coalescence

$$\frac{1}{N}$$

$$P_c(t) = \frac{1}{N} \left(1 - \frac{1}{N}\right)^{t-1}$$

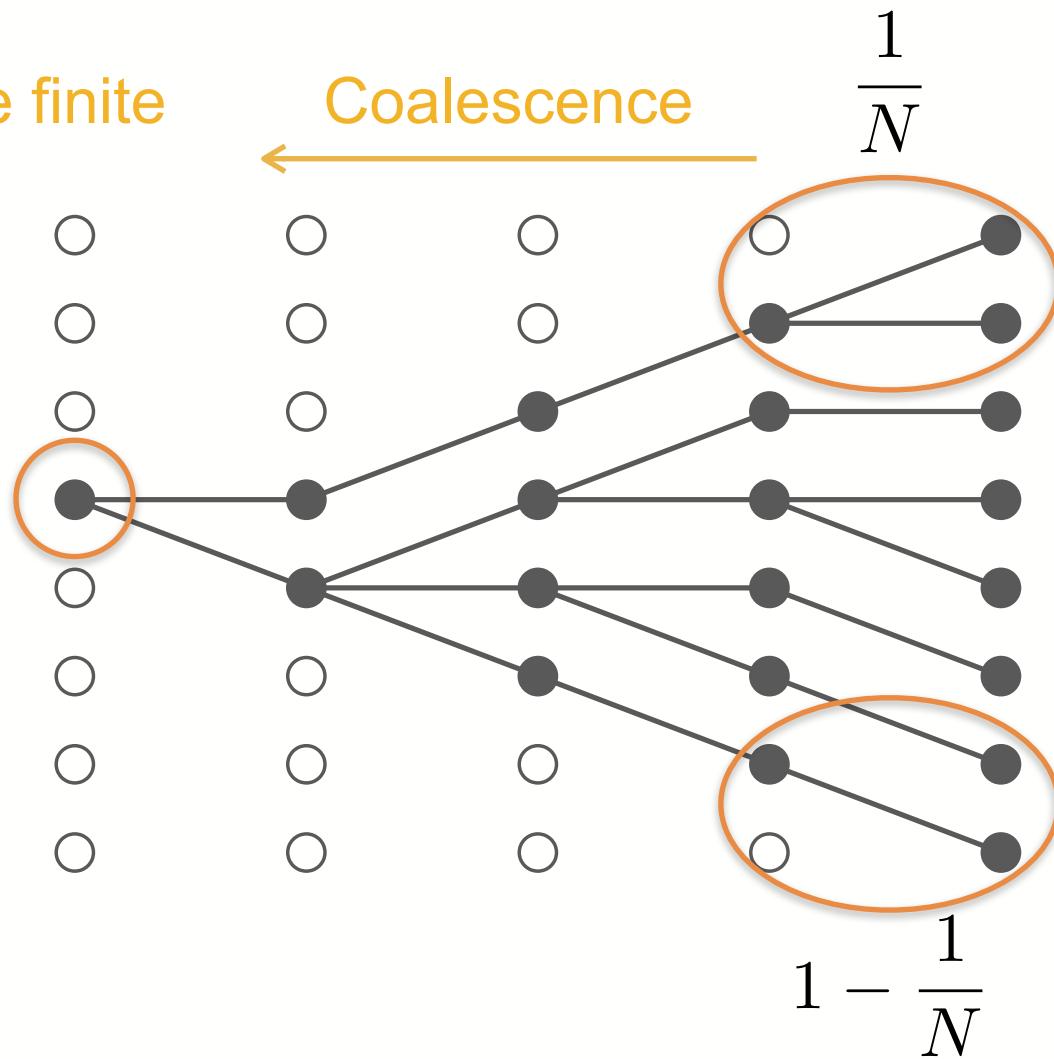


$$1 - \frac{1}{N}$$

# Reproduction (+ heritability)

Populations are finite

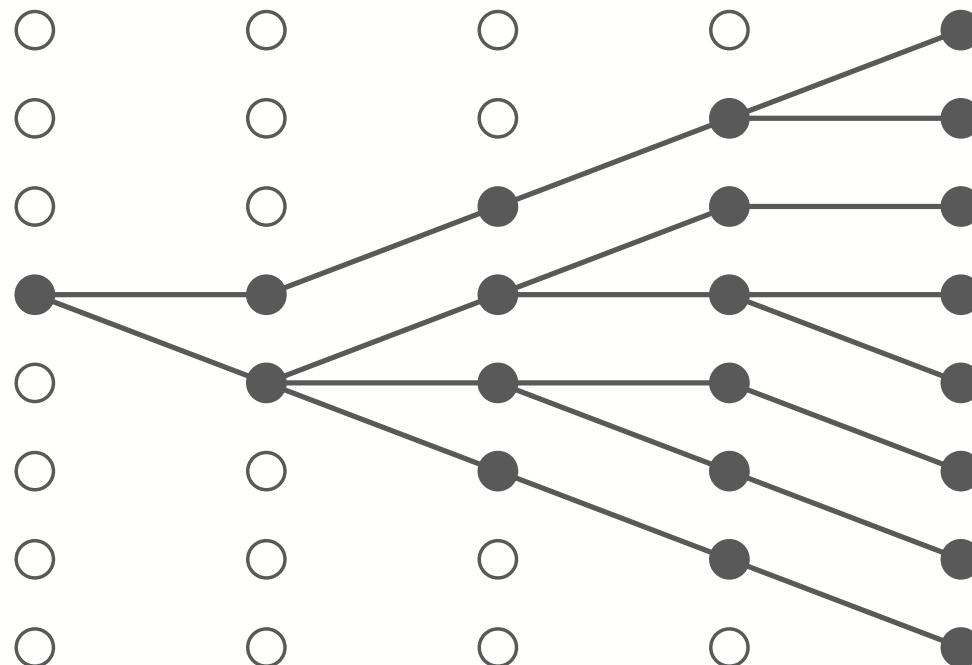
$$\lim_{N \rightarrow \infty} P_c(t) = \frac{1}{N} e^{-\frac{t-1}{N}}$$



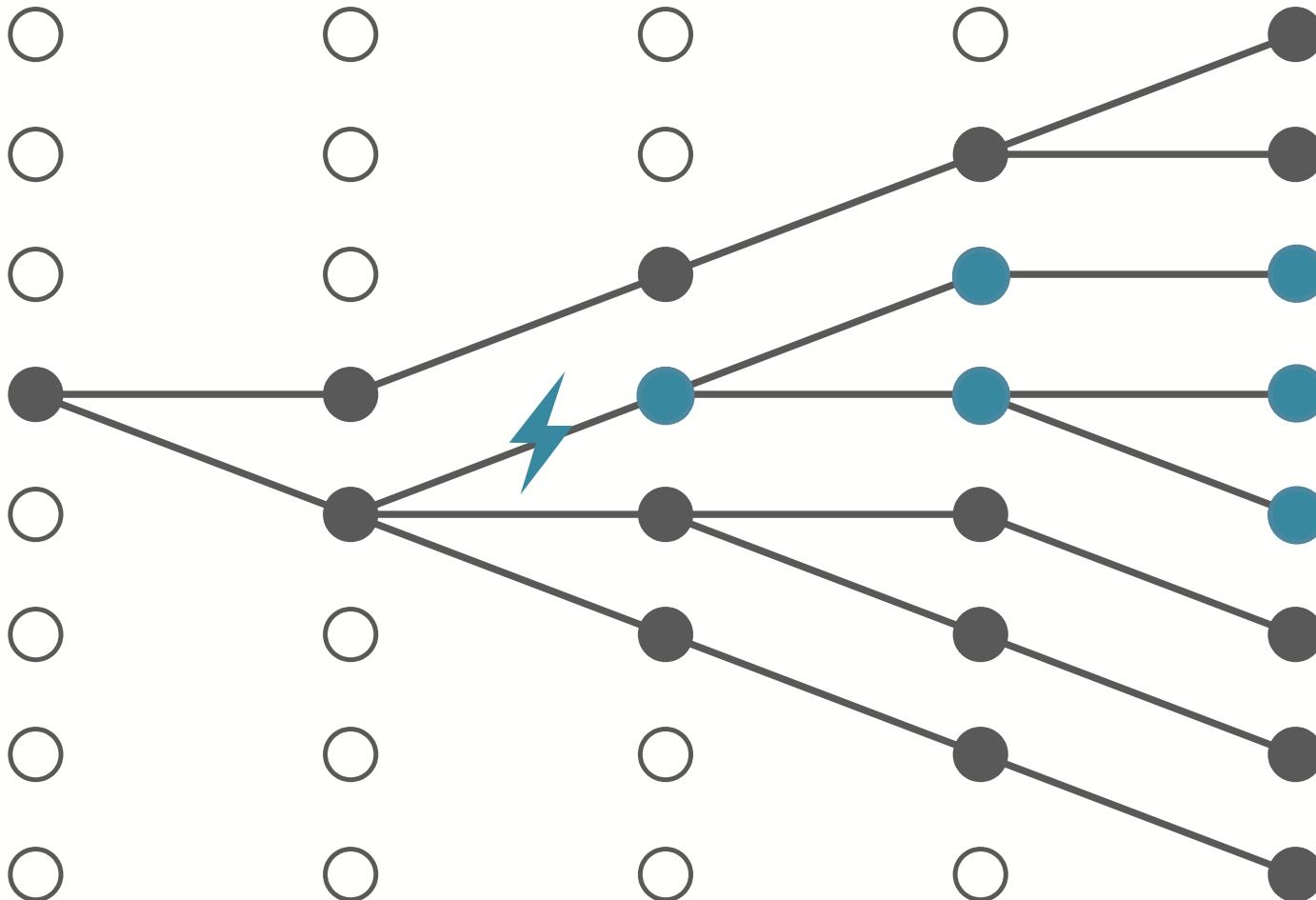
# LUCA

Because Earth is finite and very old, LUCA is less an indication of the singularity of life's origin and more a statistical artifact related to “Gambler’s ruin”

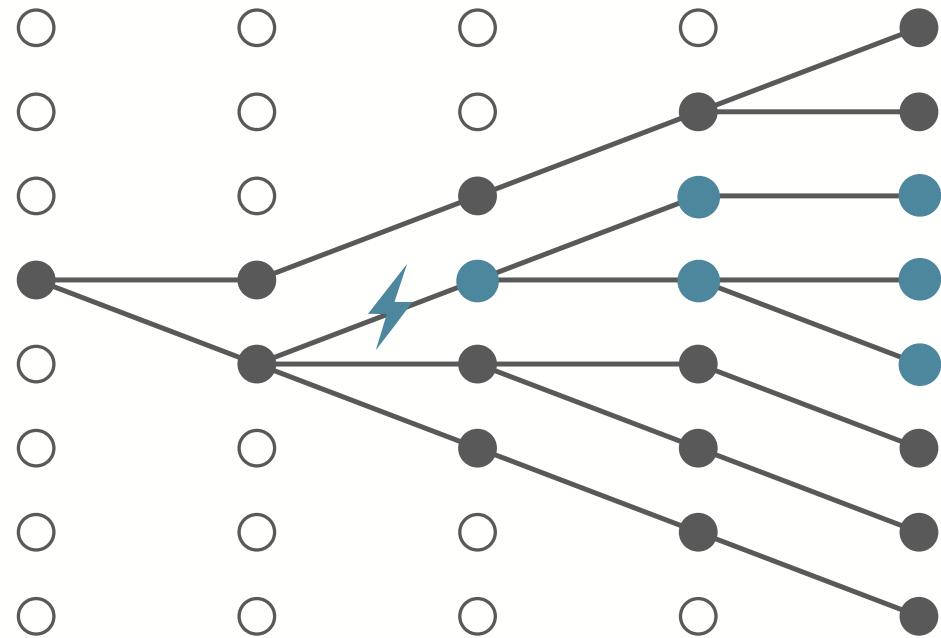
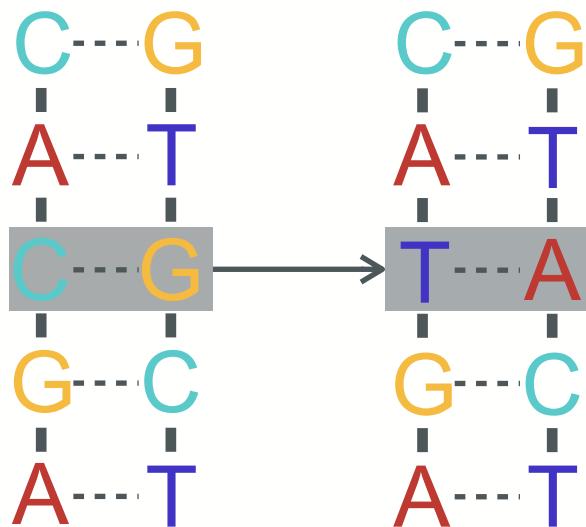
$$\lim_{N \rightarrow \infty} P_c(t) = \frac{1}{N} e^{-\frac{t-1}{N}}$$



# Mutation



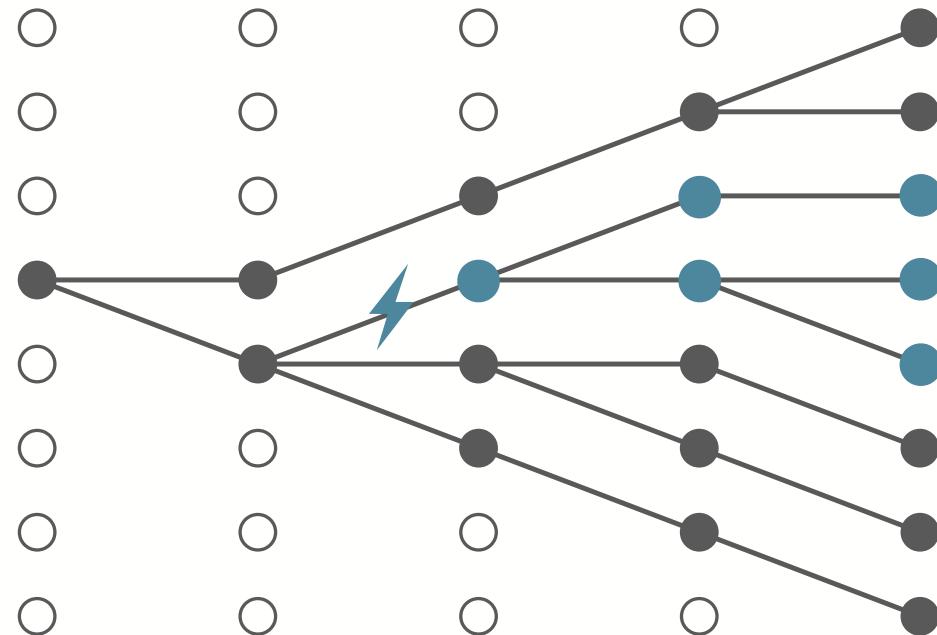
# Mutation



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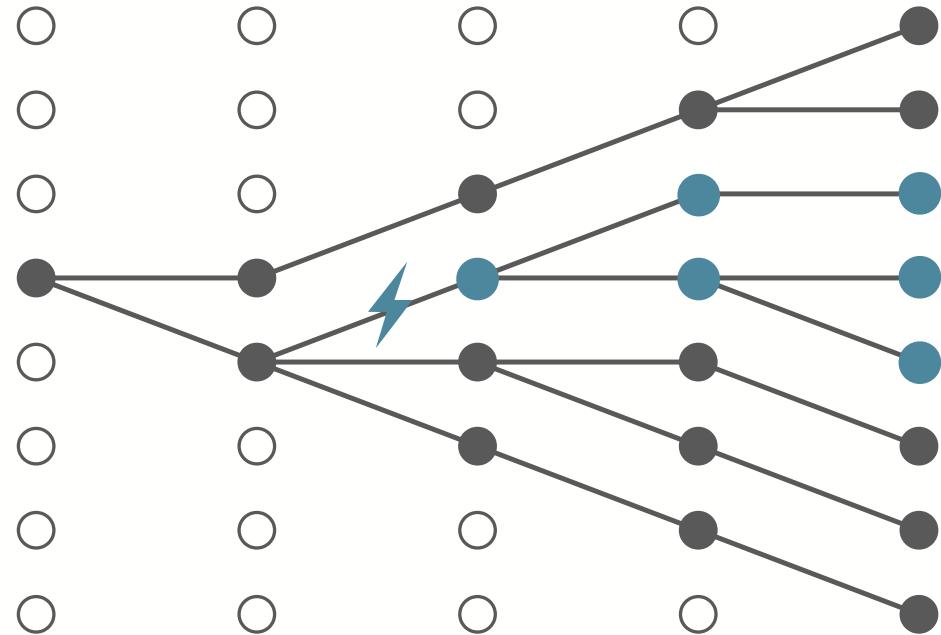
Other sources of variation:

- Insertion
- Deletion
- Inversion
- Recombination
- Migration



# Drift

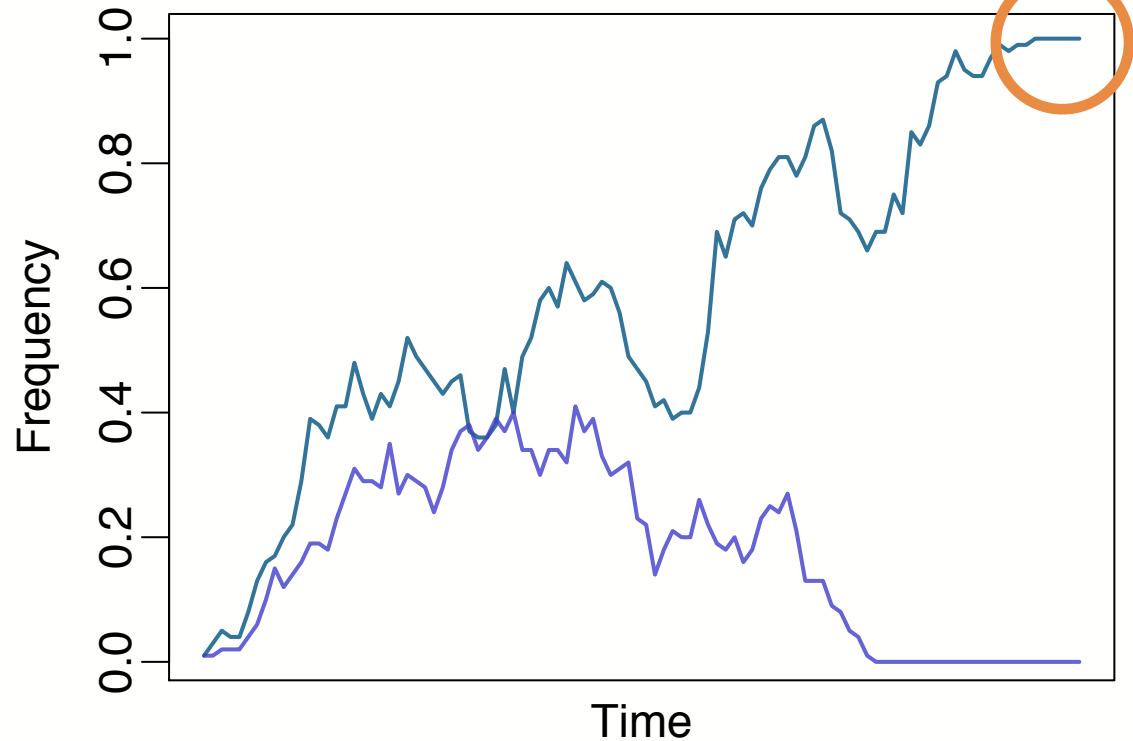
The fate of mutations without fitness consequences  
(i.e. “neutral”)



# Drift

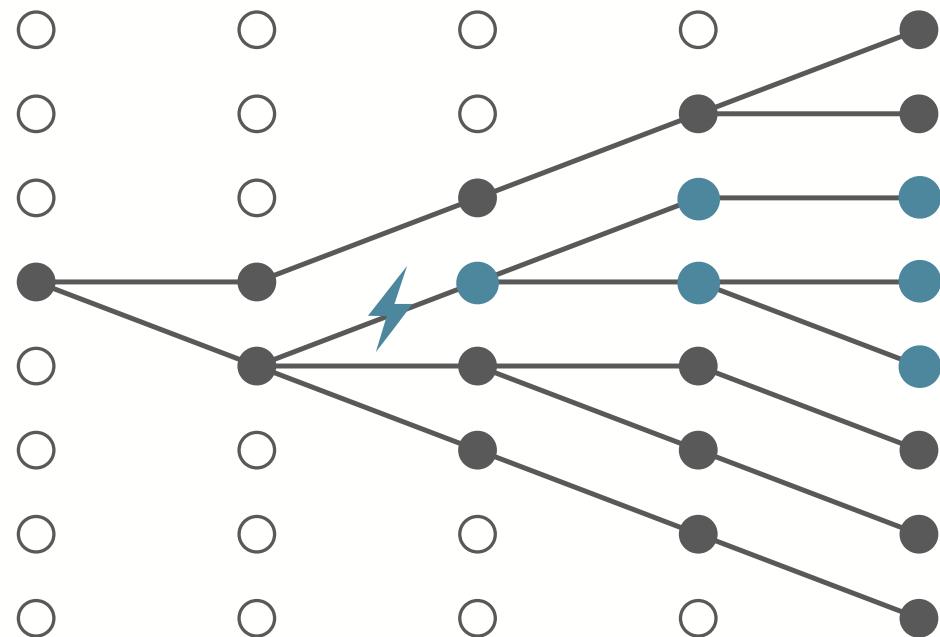
The fate of mutations without fitness consequences  
(i.e. “neutral”)

$$P_{\text{fixation}} = \frac{1}{N}$$



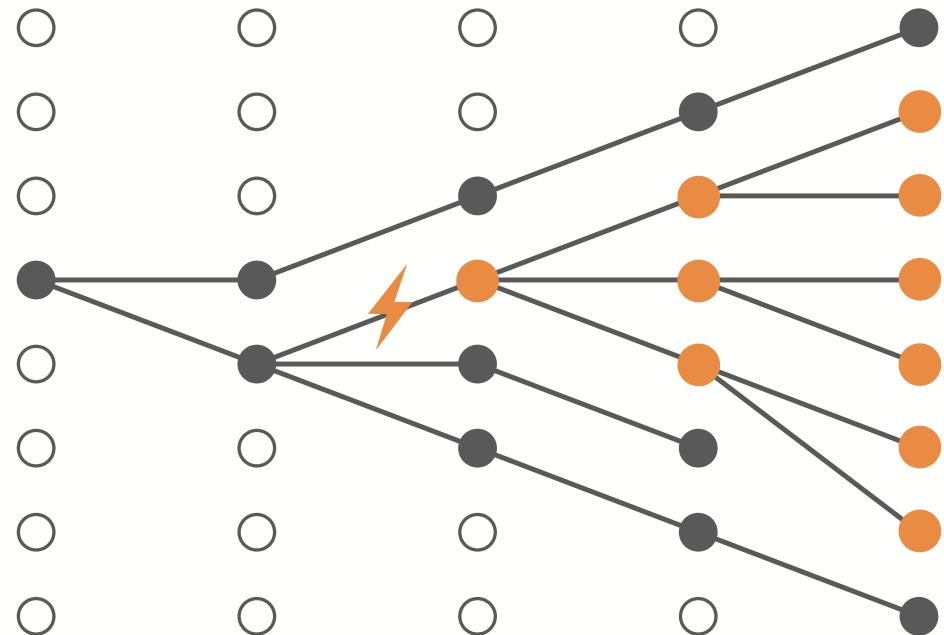
# Drift

The fate of mutations without fitness consequences  
(i.e. “neutral”)



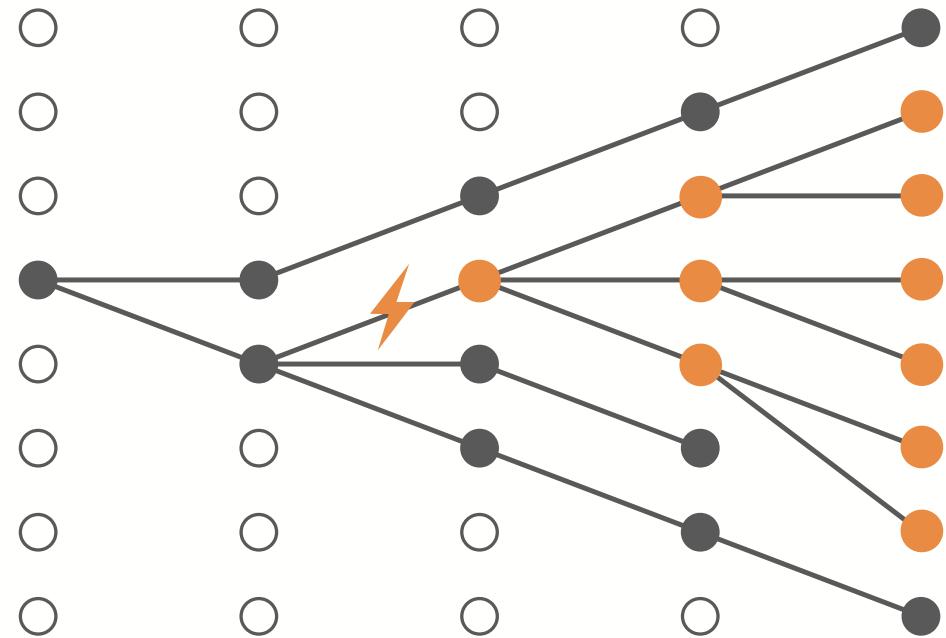
# Selection

The fate of mutations **with** fitness consequences  
("non-neutral")



# Selection

The fate of mutations **with** fitness consequences (“non-neutral”)

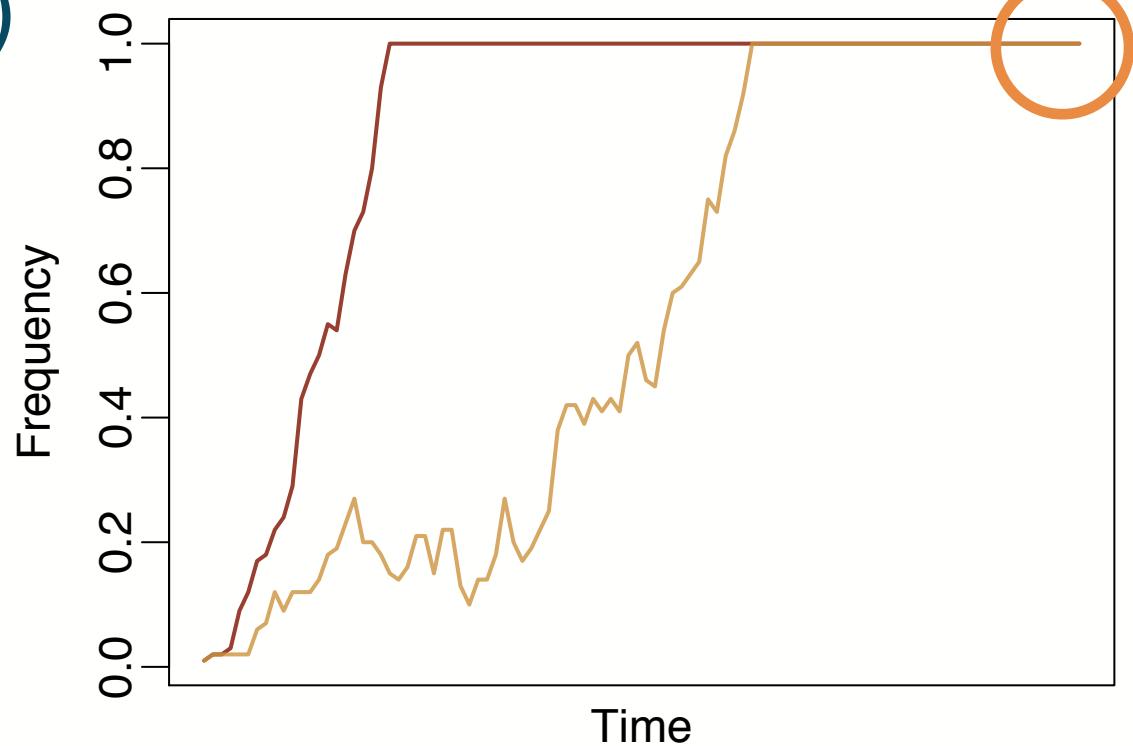


Fitness is the differential reproductive success conferred by the new mutation

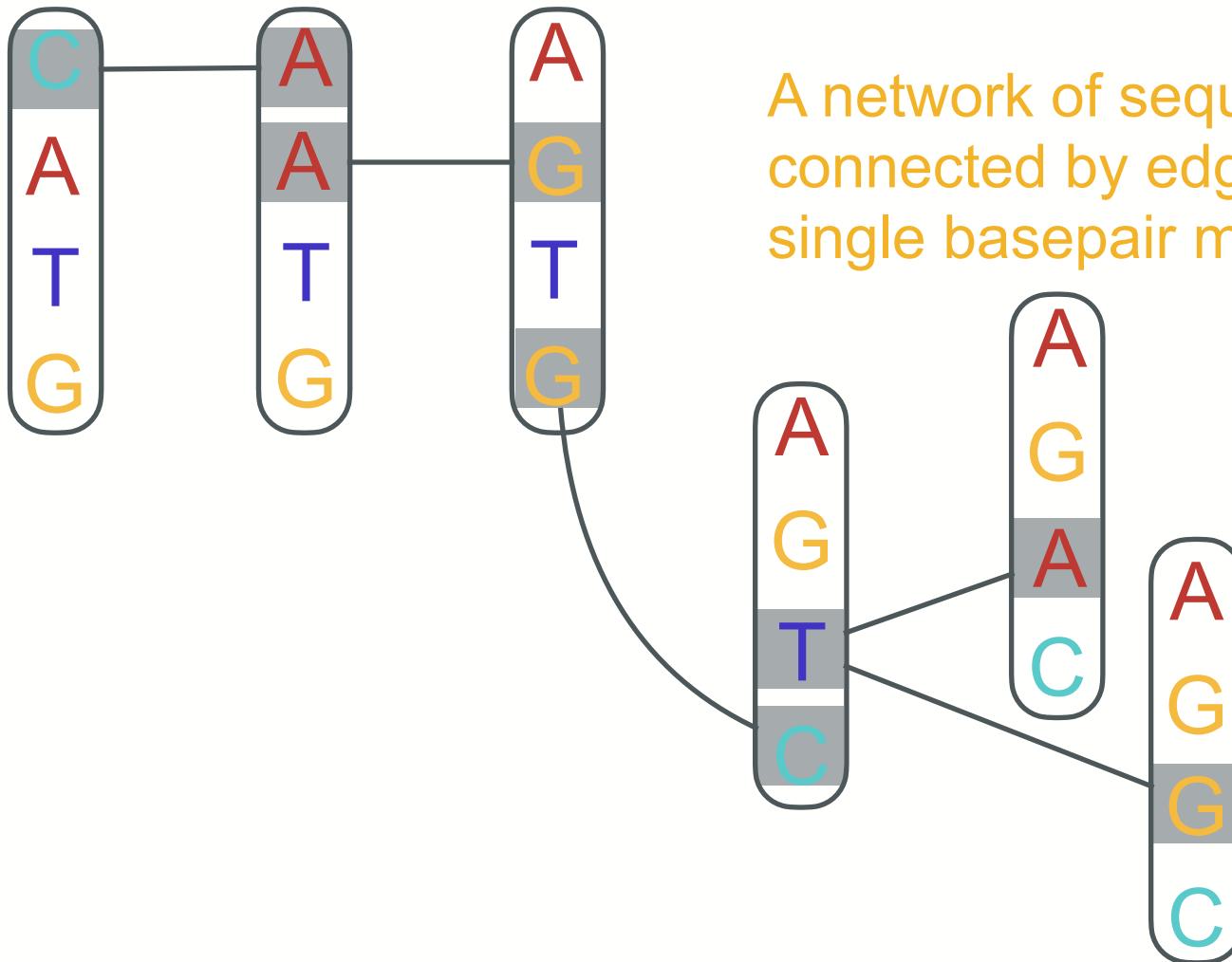
# Selection

The fate of mutations **with** fitness consequences (“non-neutral”)

$$P_{\text{fixation}} \approx \frac{1 - e^{-2s}}{1 - e^{-2sN}}$$

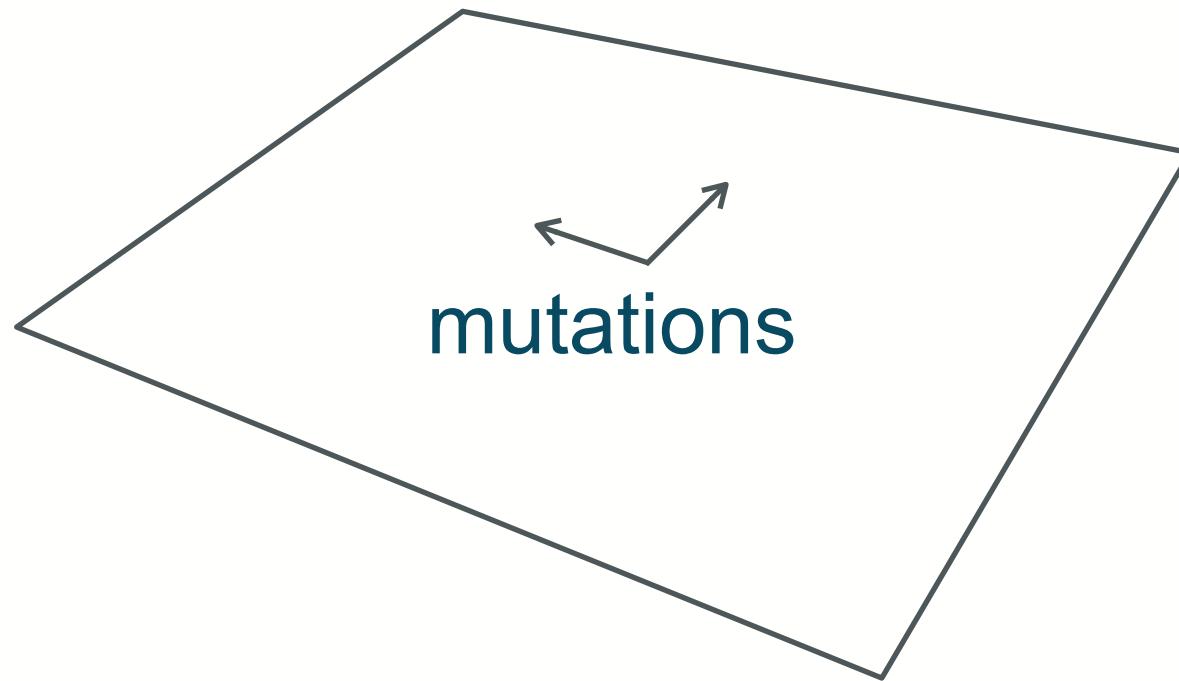


# Mutations and sequence spaces

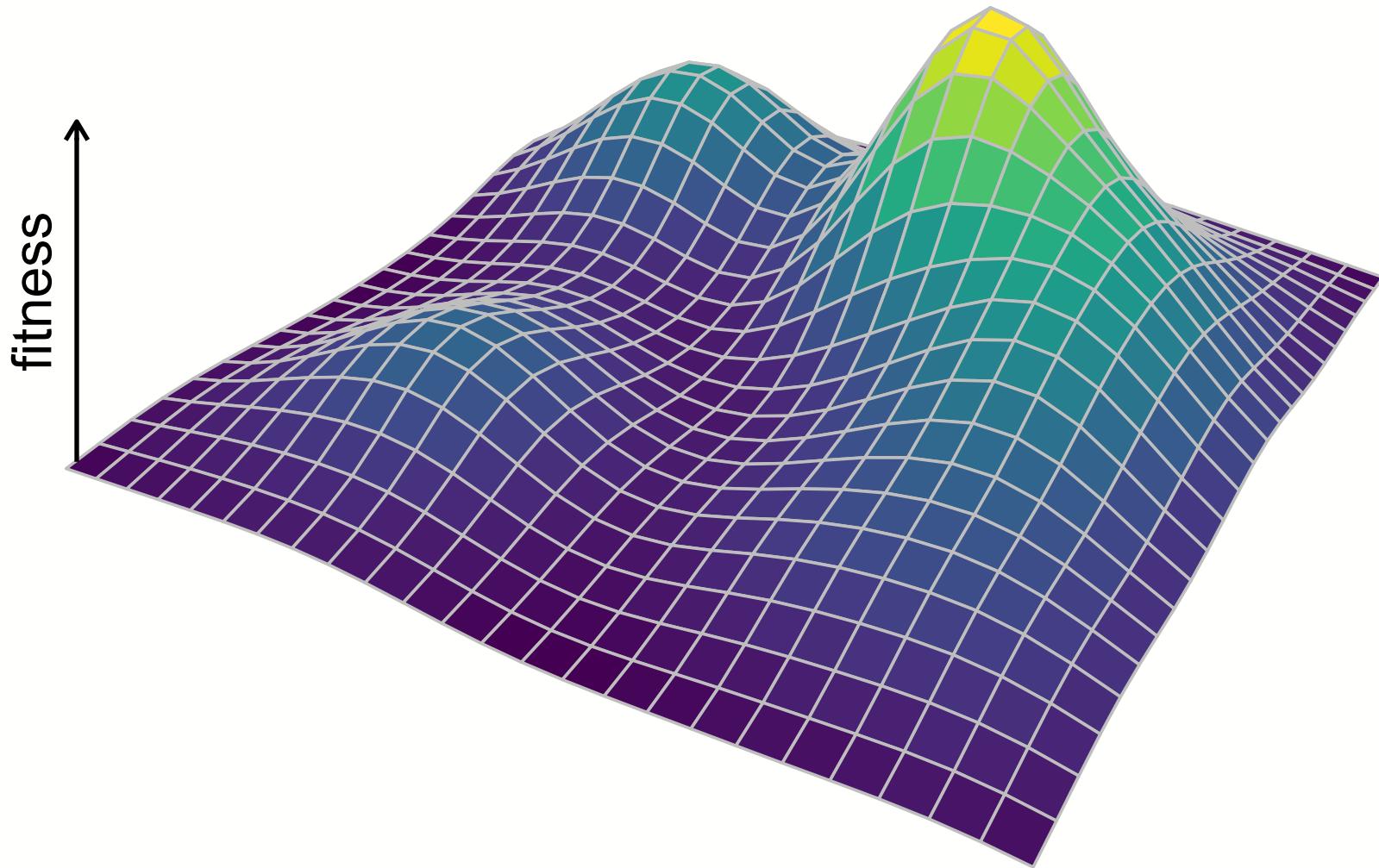


# Fitness landscapes

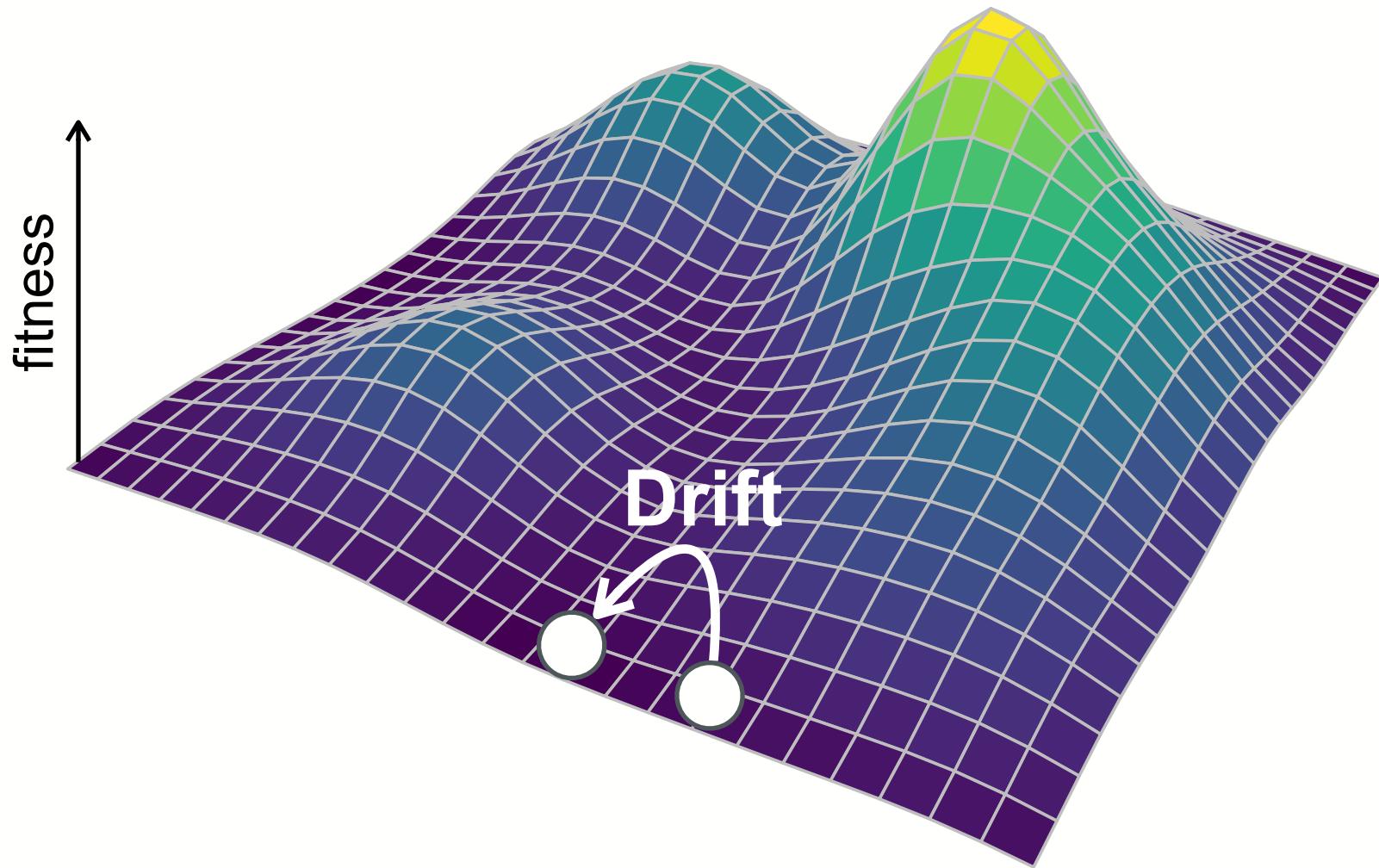
space of possible sequences



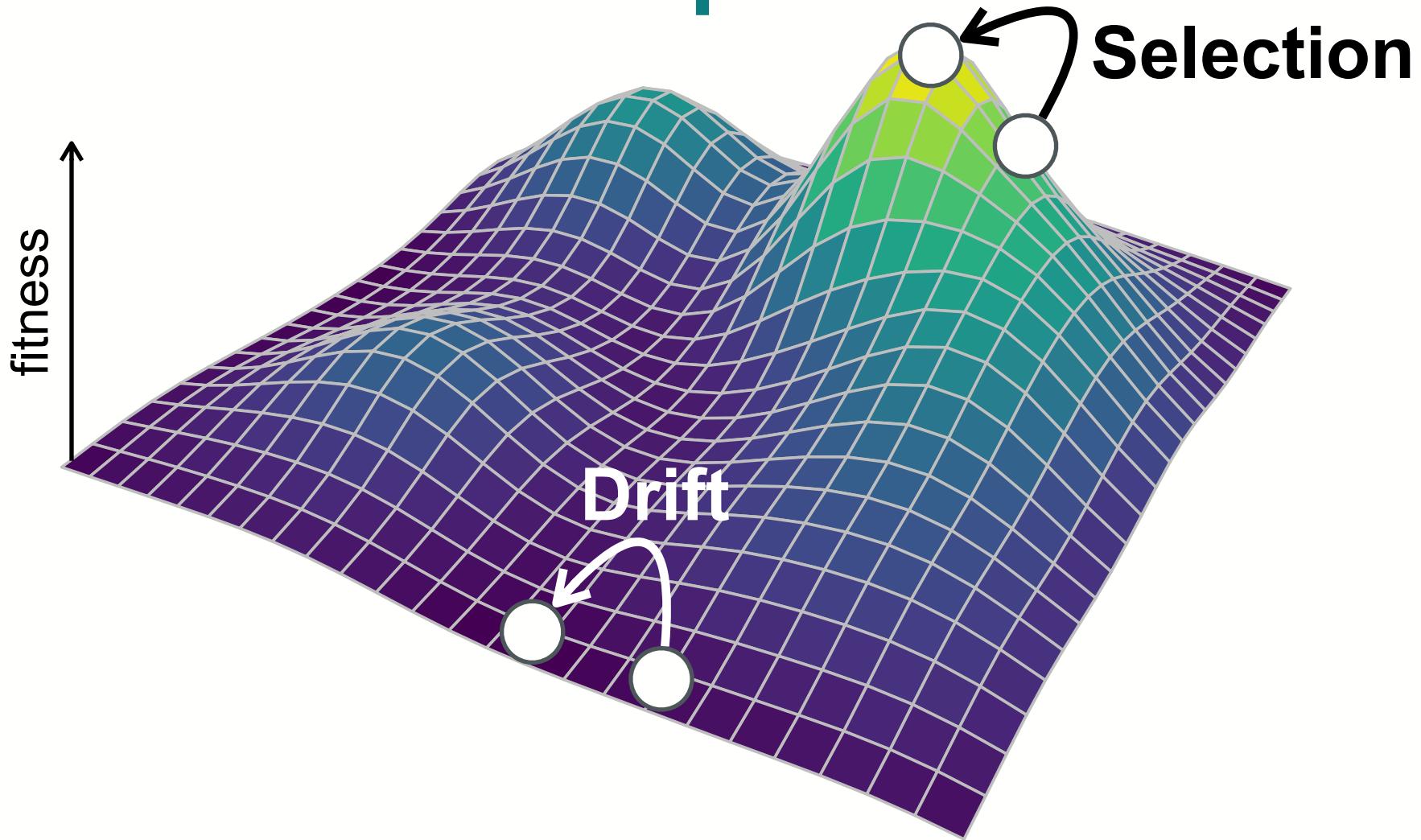
# Fitness landscapes



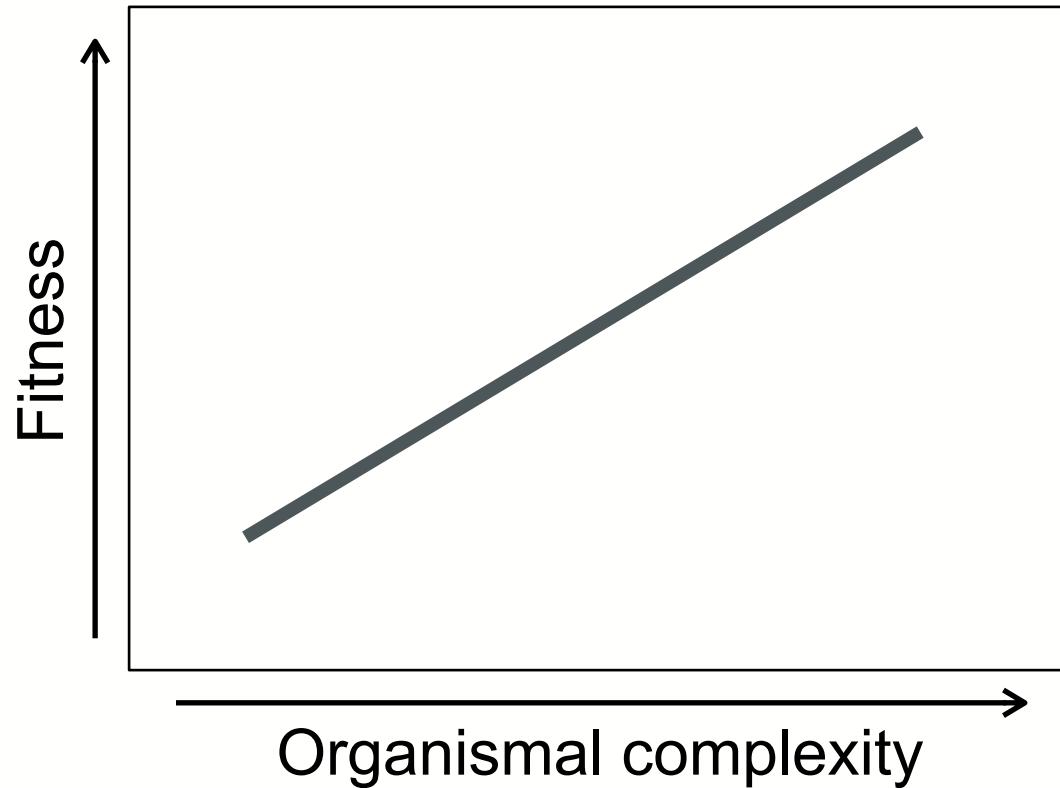
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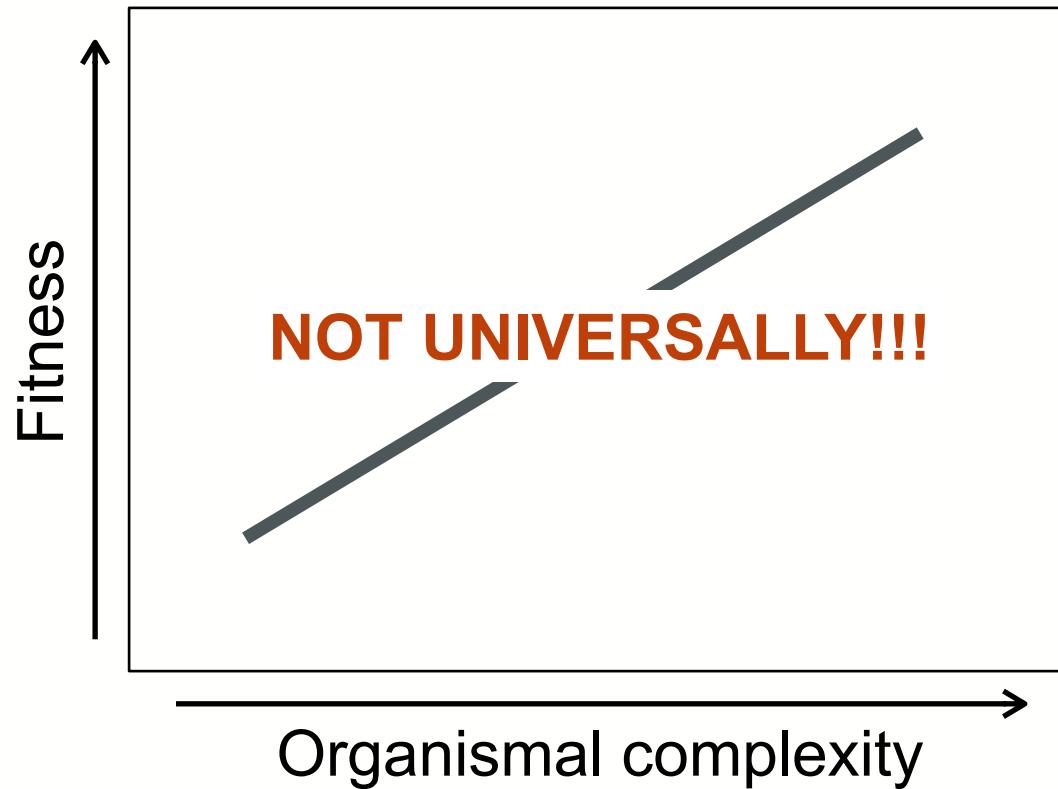
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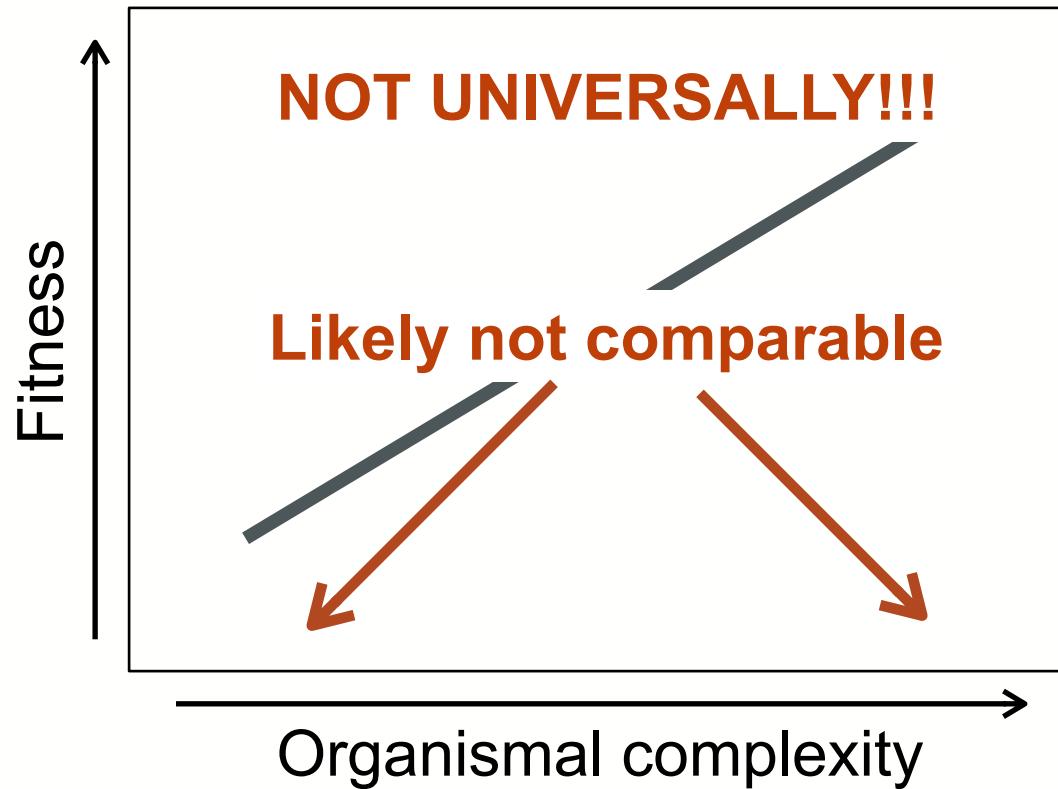
# Fitness and complexity



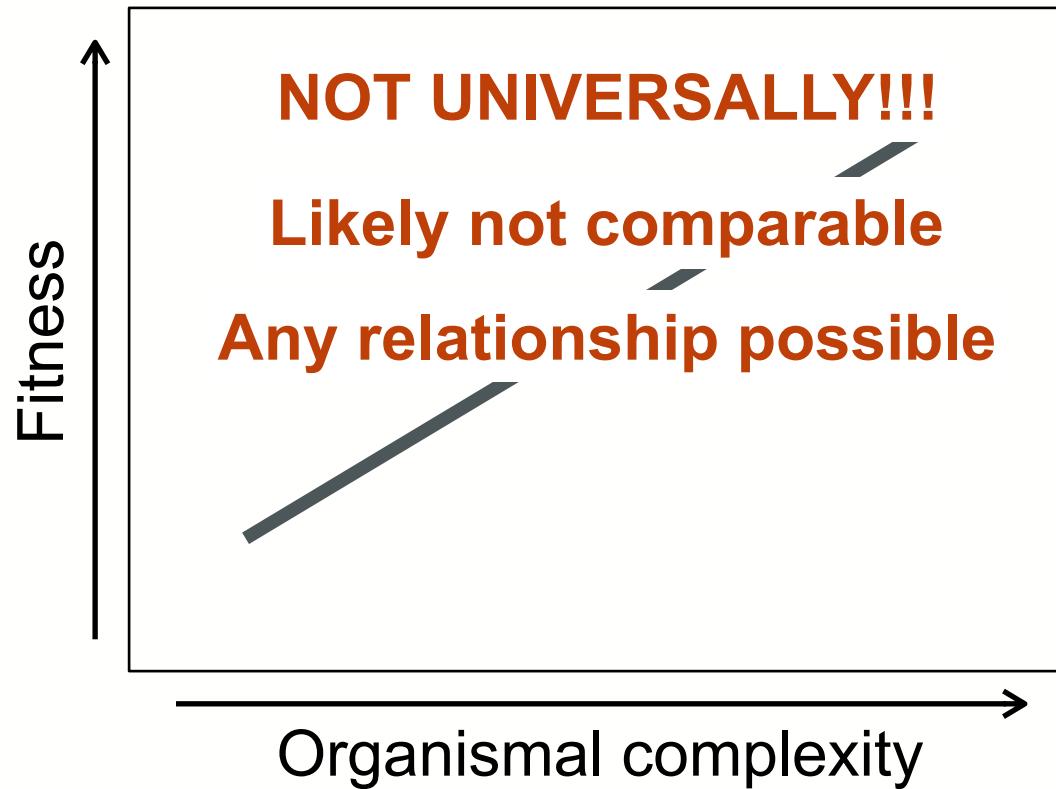
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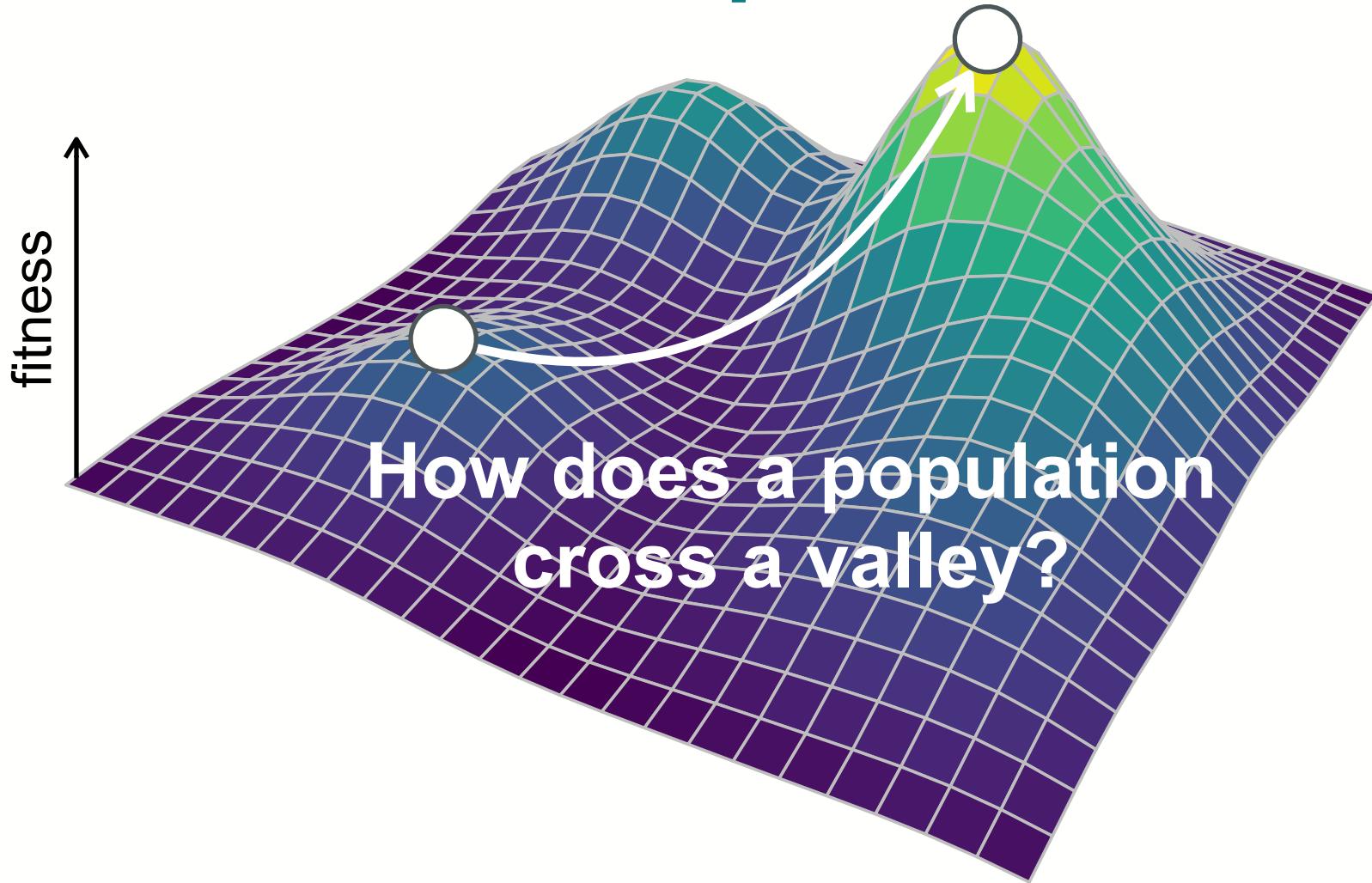
# Fitness and complexity



# Real world complexities

- Fluctuating population sizes
- Non-random mating
- Fluctuating environments and variable selection

# Real world complexities



# References and Suggested Reading

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