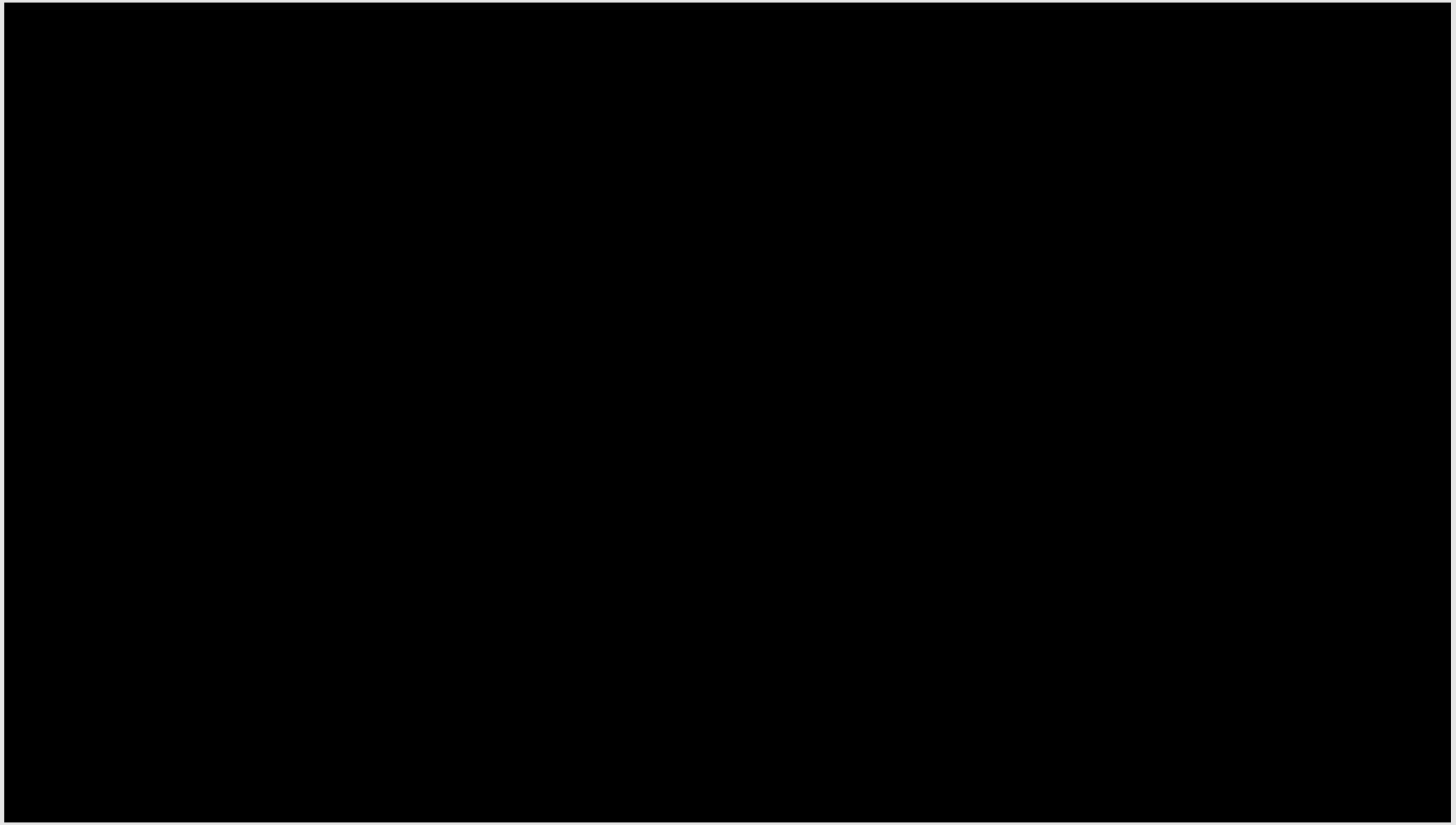
Natural Selection



http://www.youtube.com/watch?v=I0YTBj0WHkU

https://brianomeara.shinyapps.io/mutation_selection_shiny/

Brian O'Meara

EEB464 Fall 2019

Learning objectives

- Review basics of natural selection
- Think about mutation selection balance
- Consider ongoing selection in humans

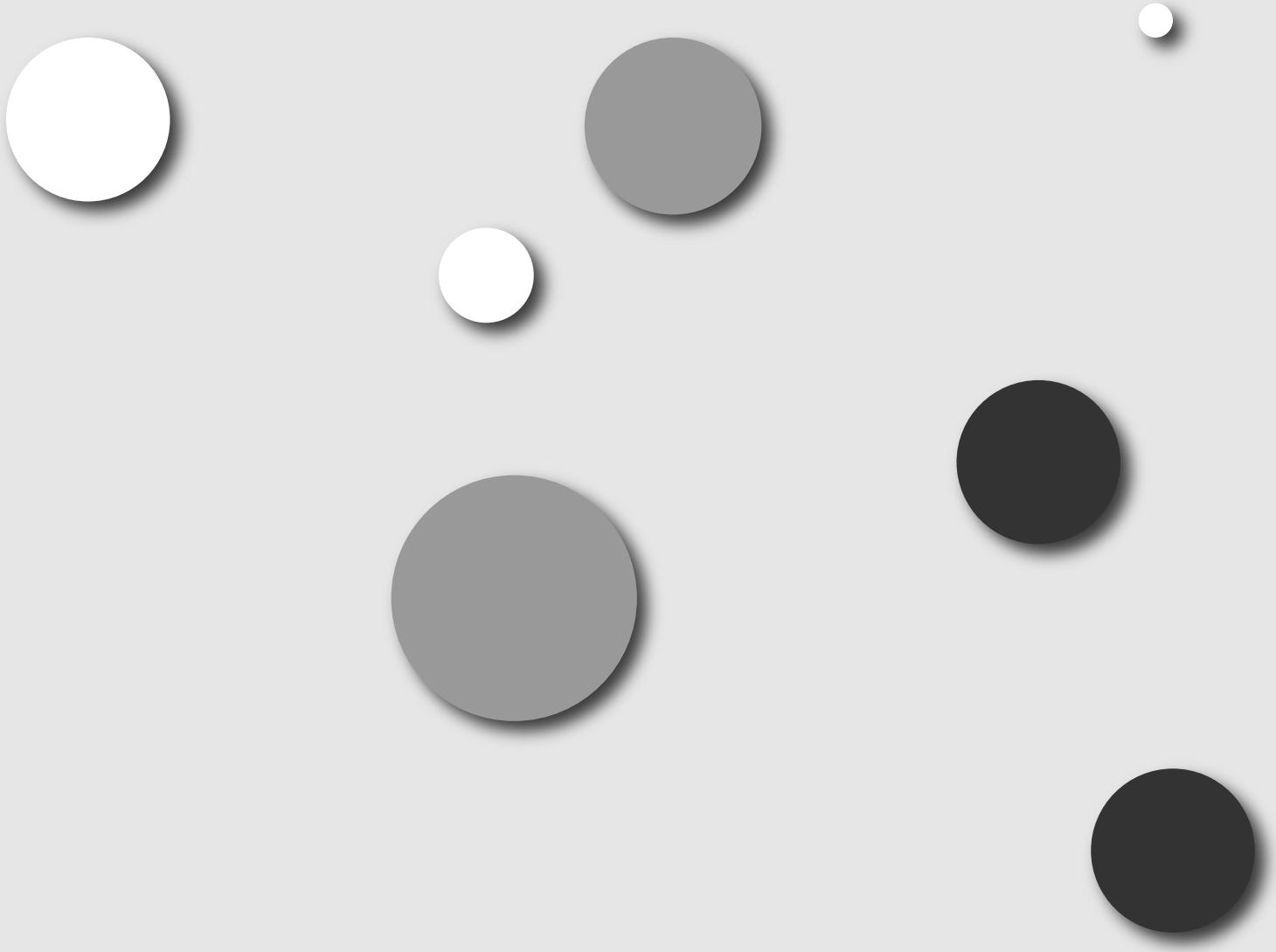
What is required for natural selection
Selection versus drift versus mutational bias
Frequency dependent selection
Balancing selection
Selection now

What is required for natural selection?

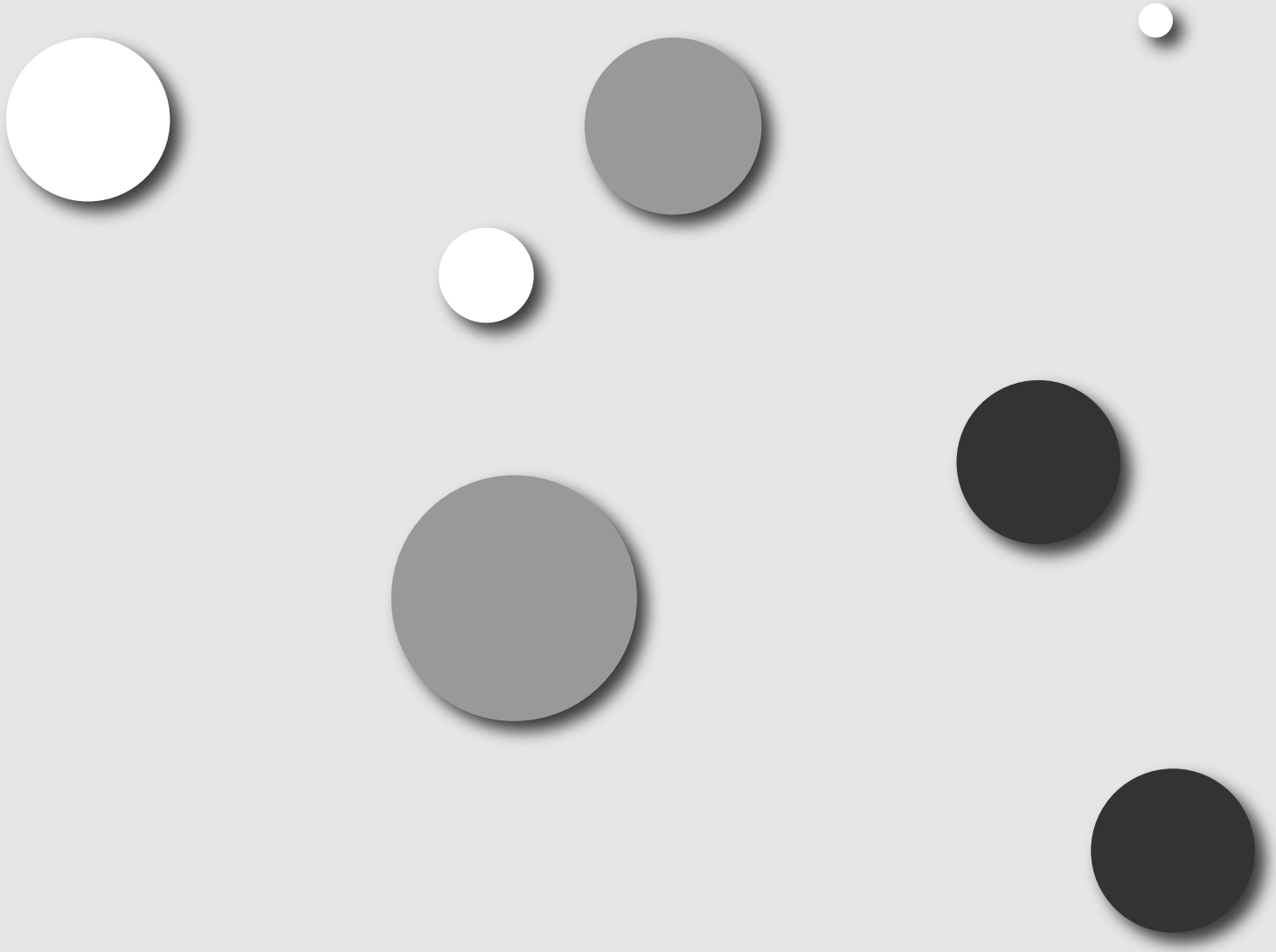
Discuss in groups, then we will select the best definition

(pun intended, as always)

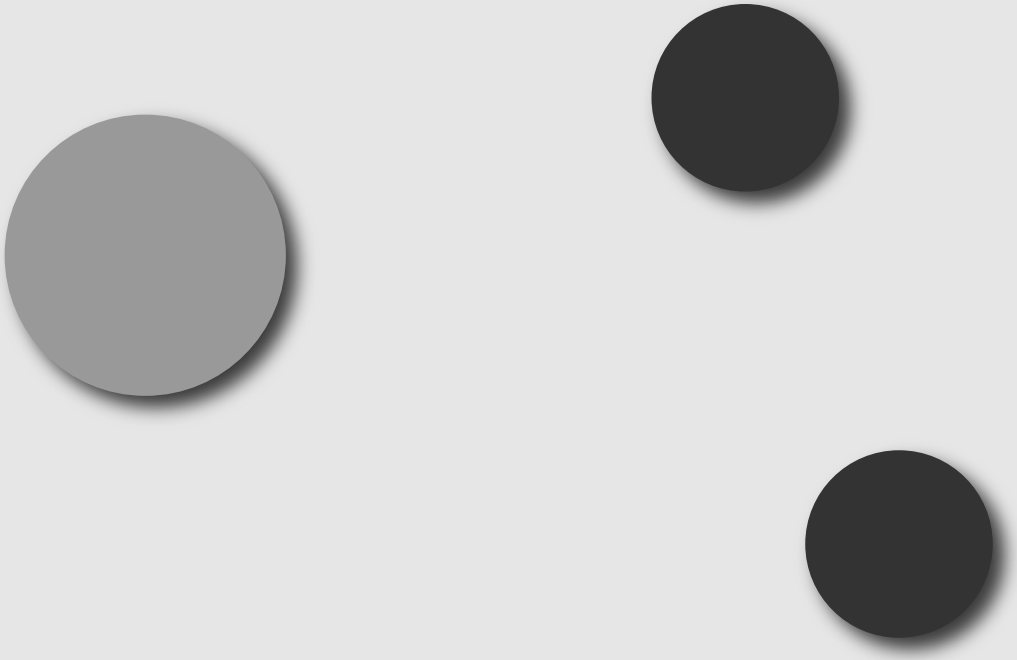
Variation



Selection



Reproduction
(with heritable traits, and some variation)

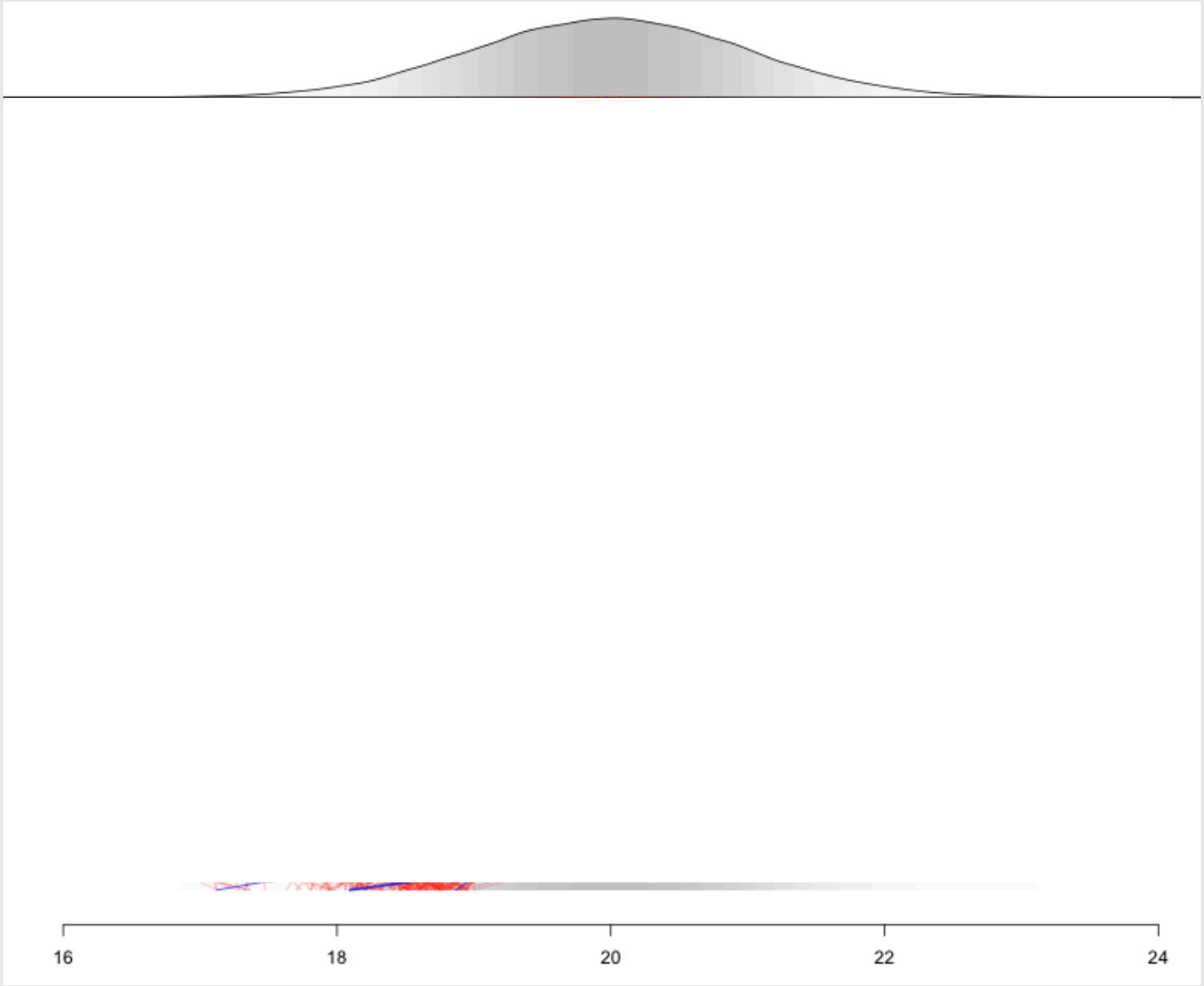


1. Organisms within a population vary

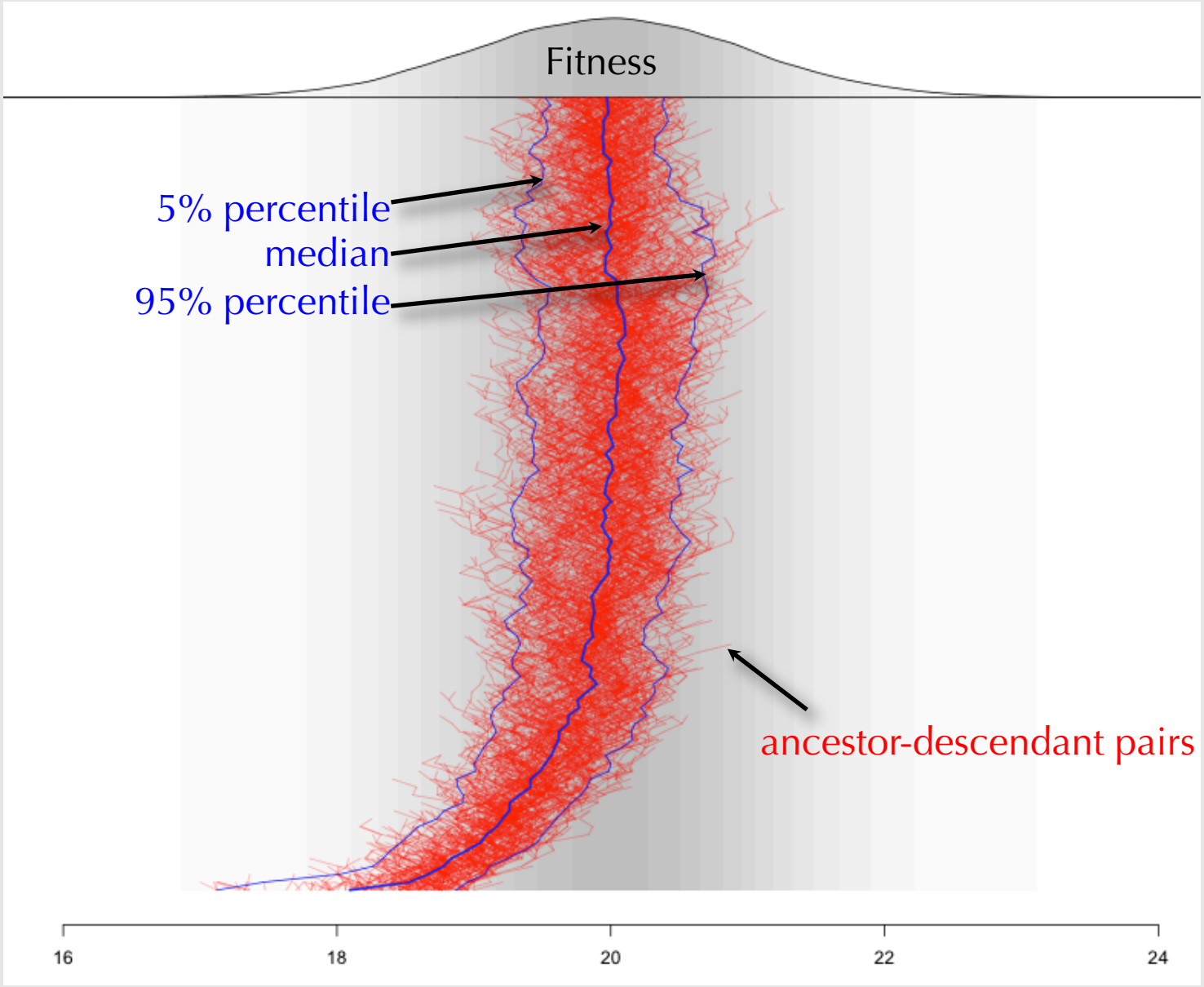
2. Some of these variations are heritable

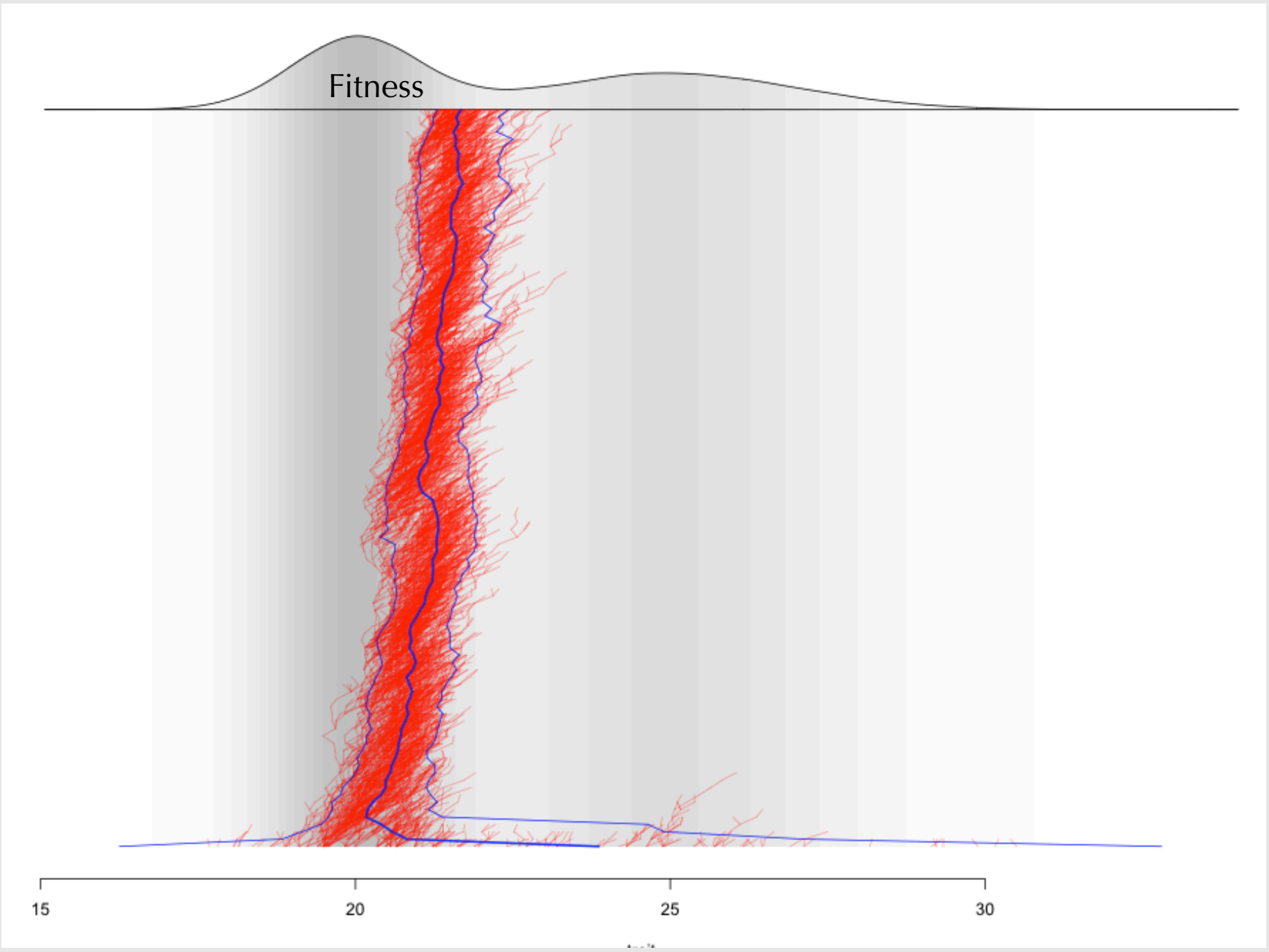
3. More offspring are produced than can survive

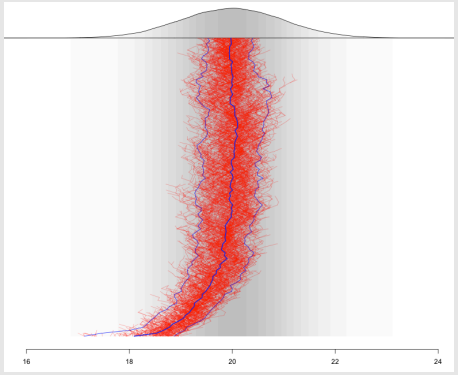
4. Individuals with certain heritable traits are more likely to survive and reproduce



https://brianomeara.shinyapps.io/mutation_selection_shiny/


Fitness
5% percentile
median
95% percentile
ancestor-descendant pairs
16
18
20
22
24


Fitness
15
20
25
30



Try giving parameters to model:

- Mutation selection balance
- Multiple optima
- Drift only
- Etc.

Balancing selection: selection maintaining diversity

Balancing selection: selection maintaining diversity

Heterozygote advantage

Malaria

aa

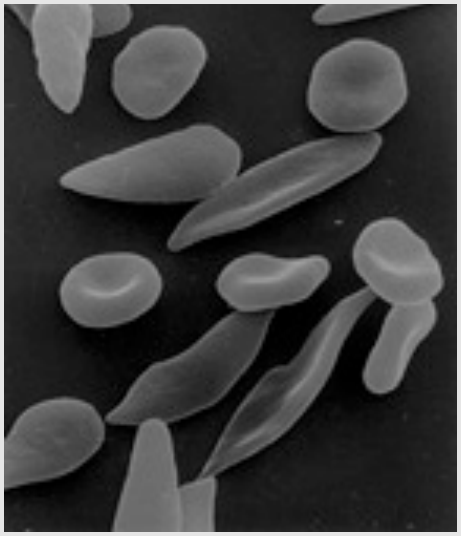
Aa + Aa

Sickle cell anemia

AA

aa Aa Aa AA

©Muhammad Mahdi Karim



Balancing selection: selection maintaining diversity

https://www.youtube.com/watch?v=M2s1CBSXCVs

Balancing selection: selection maintaining diversity

Lee et al. 2015. 10.1002/ece3.1691

Balancing selection: selection maintaining diversity

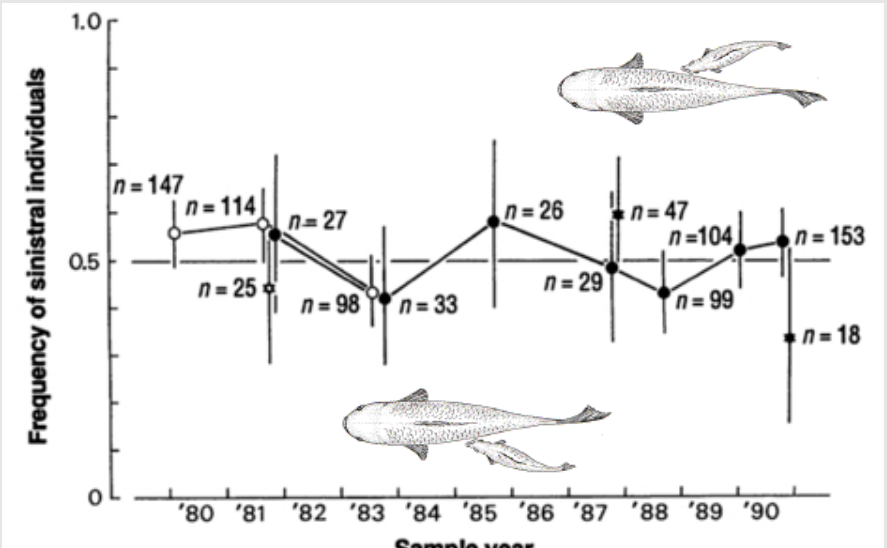
Frequency-dependent selection

Table 1. Correspondence between the handedness of *P. microlepis* and the flank of prey attacked. This experiment was done under natural conditions with adults of *Cyathopharynx furcifer*, an abundant and common prey species of *P. microlepis* (*13*), as lures. Each live *C. furcifer* individual was connected by a hook to a fishing line and allowed to swim; each *P. microlepis* that attacked the lure was caught by gill net.

Handedness of *P. microlepis*	Observations (*n*)	Attacks on flank (*n*)	
		Right	Left
Dextral	4	0	4
Sinistral	9	9	0

Table 2. Occurrence of right and left pored scales in the stomach of *P. microlepis*. The handedness of scales was determined under a binocular microscope on the basis of the shape of the exposed granulated portion and the number of basal ridges in the upper and lower parts separated by the mucous tube. Unknown scales are those misshapen as a result of partial digestion and those of abnormal shape.

Handedness of *P. microlepis*	Fish (*n*)	Pored scales (*n*)		
		Right	Left	Unknown
Dextral	32	0	139	31
Sinistral	24	76	0	23



Hori 1993; images from http://bio.research.ucsc.edu/~barrylab/classes/evolution/NS_H2.HTM

Note story is more complex than this: Palmer (2010)

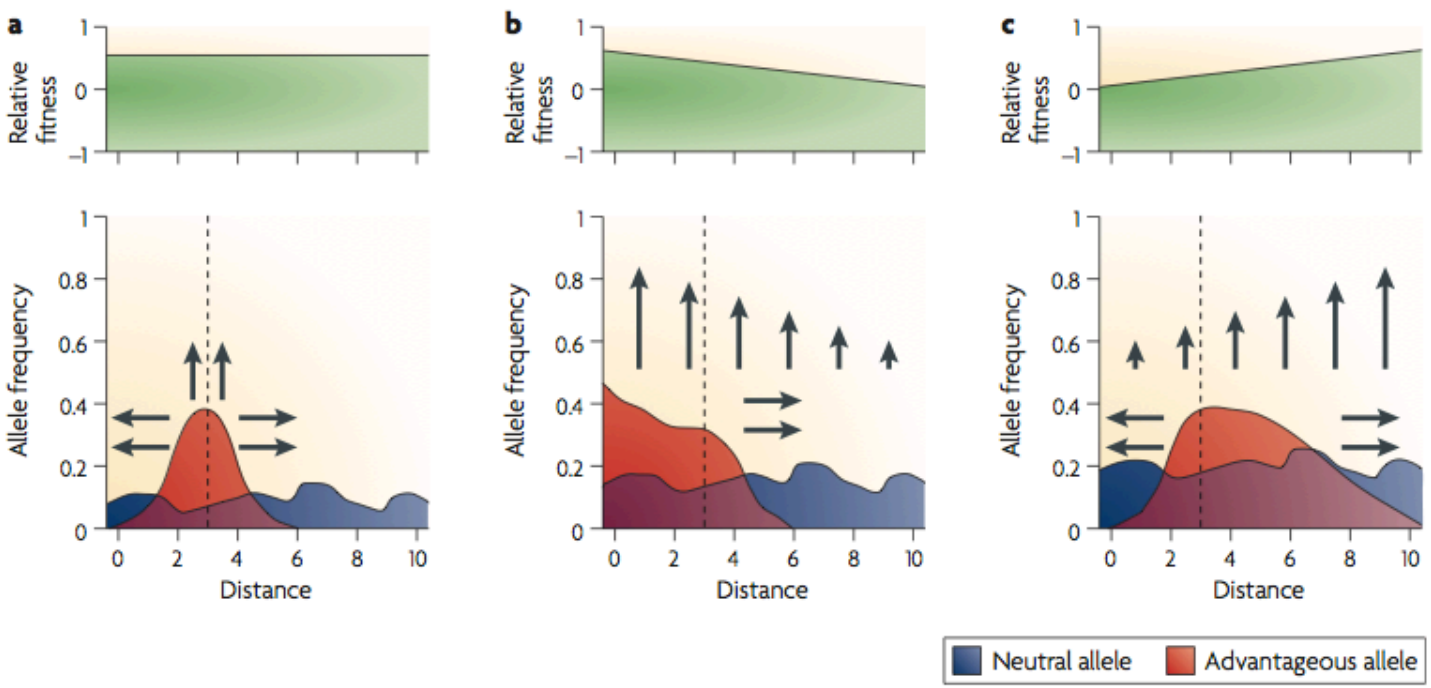


Figure 1 | **The 'wave of advance' spread of a globally advantageous mutation.** Arrows indicate how the allele frequencies of a selected allele (red) are expected to change over time, depending on the pattern of selective advantage of the allele (indicated in green above each graph). Vertical arrows represent the expected magnitude of increase due to selection. Horizontal arrows represent how dispersal homogenizes allele frequencies across space. For every selected allele, a representative neutral allele (blue) of similar average frequency is shown for comparison. In each case the allele arose at location 3 on the *x* axis (marked with a vertical dashed line); the spread will continue until the selected allele is at frequency 1 across the whole habitat. **a** | Uniform selective advantage across space. If the new variant is identically advantageous everywhere, then as the variant increases in frequency it will become exceptionally concentrated around its geographic origin relative to a neutral variant of the same age. One effect of this is the creation of transiently enhanced levels of divergence among populations and clines in allele frequencies that reflect the geographic origin of the allele. **b**,**c** | Non-uniform advantage across space. In scenario **b**, the novel allele is introduced to the regions in which it is most advantageous and rapidly increases in frequency in those regions. This can lead to transient correlations between allele frequency and the environmental factor that drives positive selection. By contrast, in scenario **c**, the novel allele arises in an area distant from where it is most advantageous. It will increase in frequency locally before spreading outwards, and its distribution will carry a strong signature of its geographic origin and be less reflective of spatial variation in selective advantage. These models assume selection acting on new mutations, which may not be the prevailing scenario in humans. Selection on pre-existing variation will complicate these simple scenarios.

Novembre and Rienzo. Spatial patterns of variation due to natural selection in humans. Nature Reviews Genetics (2010) vol. 10 (11) pp. 745-755

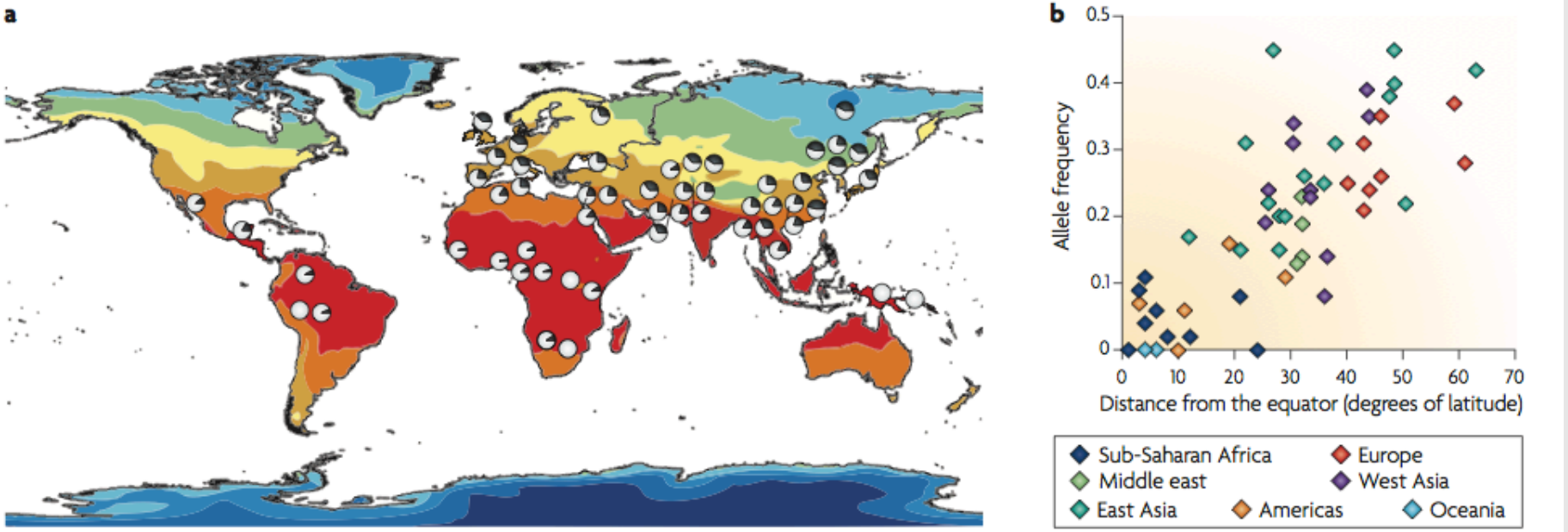


Figure 5 | **Correlation of a SNP in the *RPTOR* gene with environmental variables. a** | Pie charts show the frequency of the derived allele at SNP rs12946049 in the *RPTOR* gene in the Human Genome Diversity Project panel[53]. The colours, ranging from dark blue (cold) to red (hot), represent the maximum temperature in the winter. **b** | Allele frequency at rs12946049 as a function of distance from the equator. Qualitatively, the correlation is convincing for two reasons. First, the variation correlates strongly with an environmental feature in ways that depart from background spatial patterns (for example, distantly related populations in the tropical Americas, Oceania and sub-Saharan Africa share the same environment and have similar allele frequencies). Second, the correlation exists in multiple world regions. Figure is modified from REF. 53.

Novembre and Rienzo. Spatial patterns of variation due to natural selection in humans. Nature Reviews Genetics (2010) vol. 10 (11) pp. 745-755