

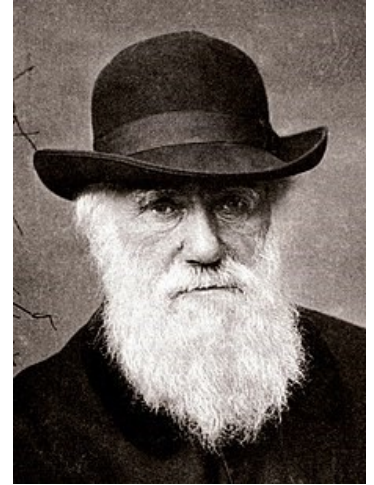
Selection

Natural selection

- Main driver of evolution
- Origin of adaptations.

Biological fitness

- The ability of an individual to transfer its genes to the next generation (i.e. survive and reproduce).



Charles Darwin



Lamarck vs. Darwin

Inheritance of
acquired characters

Random phenotypic
variability (mutations)

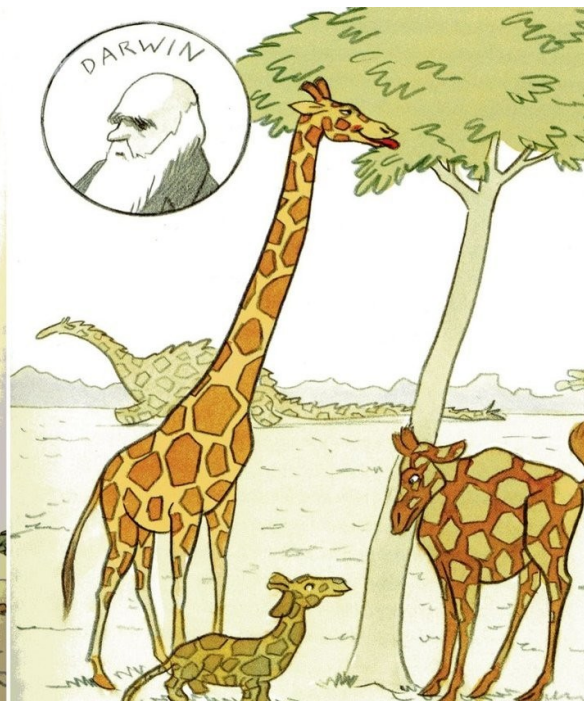
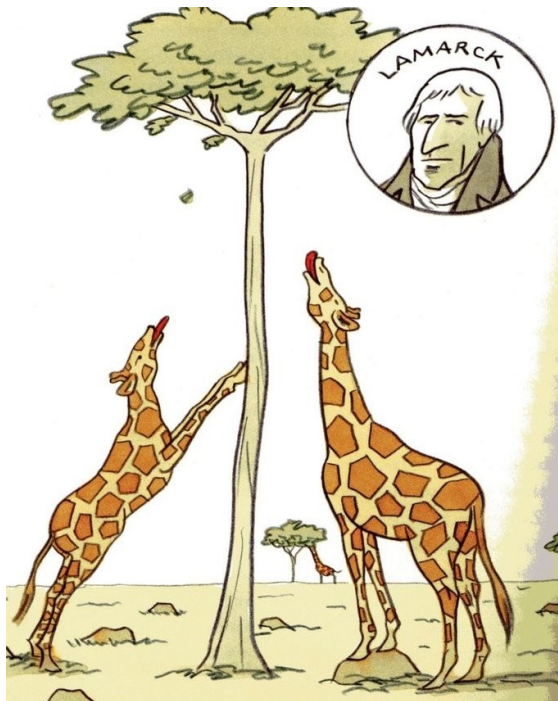
selection

inheritance

adaptation

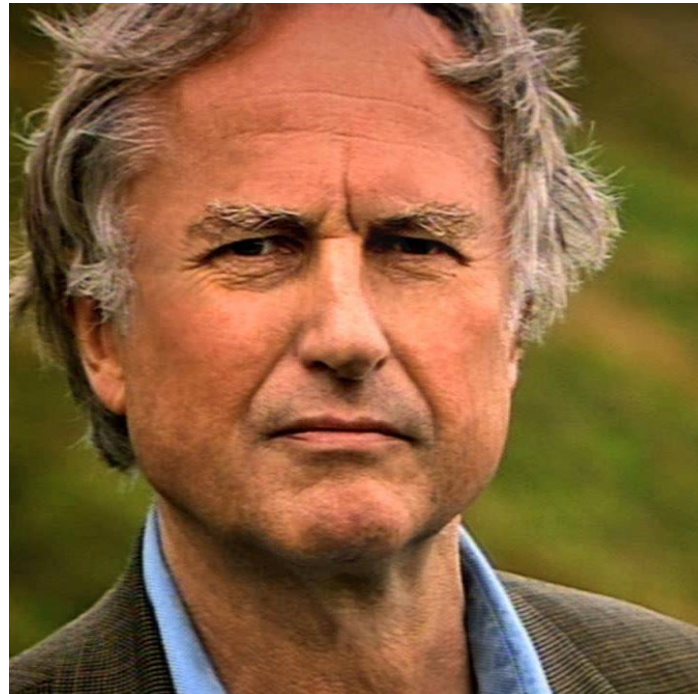
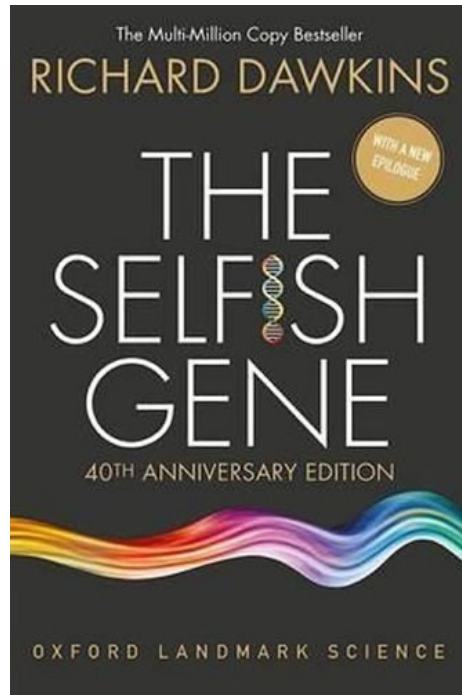


Jean Baptiste Lamarck



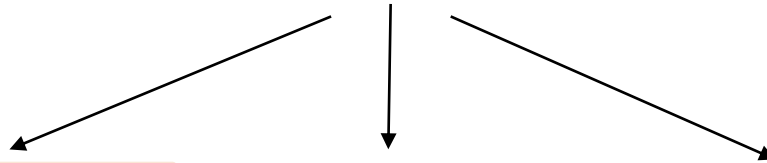
The selfish gene theory (neodarwinism)

- Genocentric view on evolution
- Competition occurs among alleles of individual genes rather than among individuals of the same species.



Selection

mutations



deleterious



Negative (purifying)
selection

neutral



advantageous






positive selection

Population genetic models of selection




Relative fitness (w)

- Relative differences in fitness between genotypes.
Maximum $w = 1$.
Minimum $w = 0$.

AA	Aa	aa
		
$w = 1$	1	0,5






Selection coefficient (s)

- Increase or decrease in fitness in particular genotype(s).

AA	Aa	aa
		
$w = 1$	1	$1 - s$

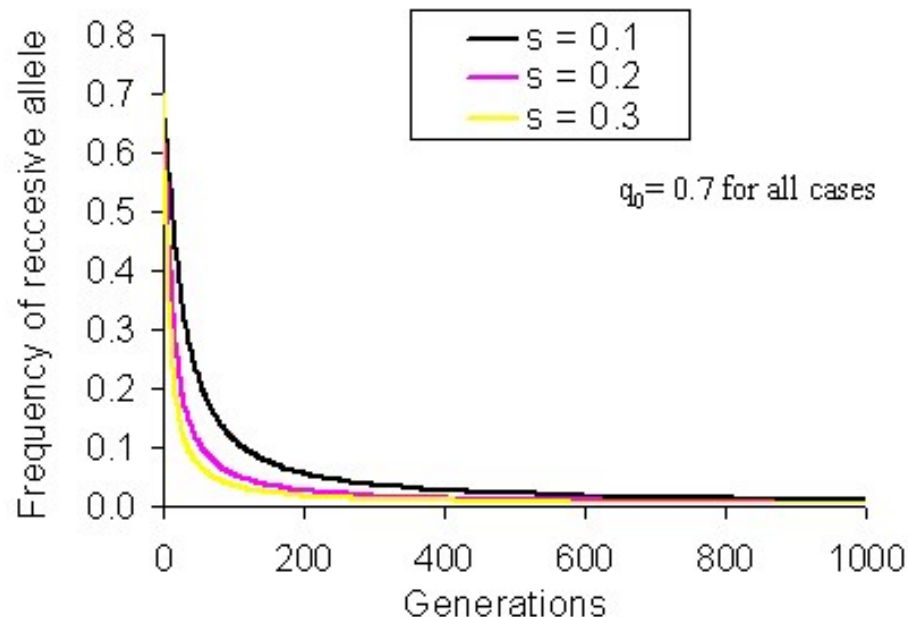
Coefficient of dominance (h)

- Level of dominance between alleles
 $h = 0$ či 1 complete dominance
 $0 < h < 1$ incomplete dominance

AA	Aa	aa
	  	
$w = 1$	$1 - hs$	$1 - s$

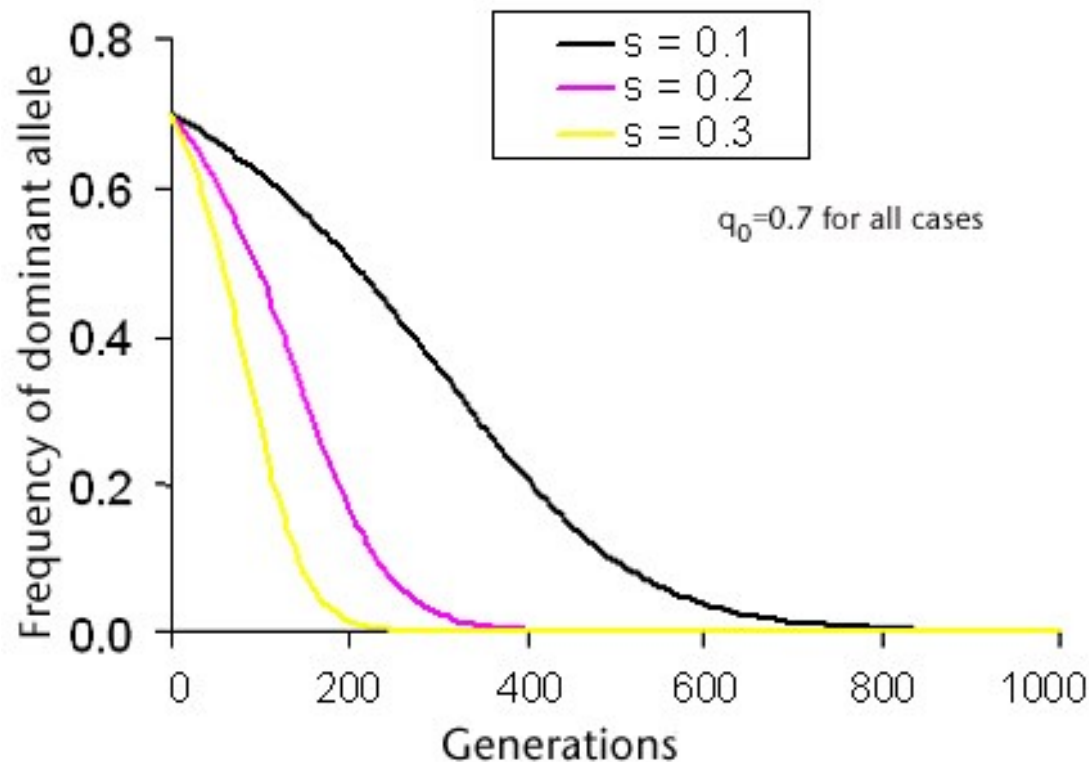
Negative selection against recessive mutations

- Reduces fitness of the deleterious mutation, but the mutation is not eliminated completely from the population if it is recessive (hidden in heterozygotes).
- Human diseases are often caused by recessive mutations (např. cystic fibrosis, phenylketonuria etc.)

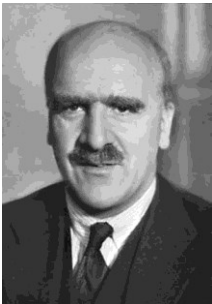
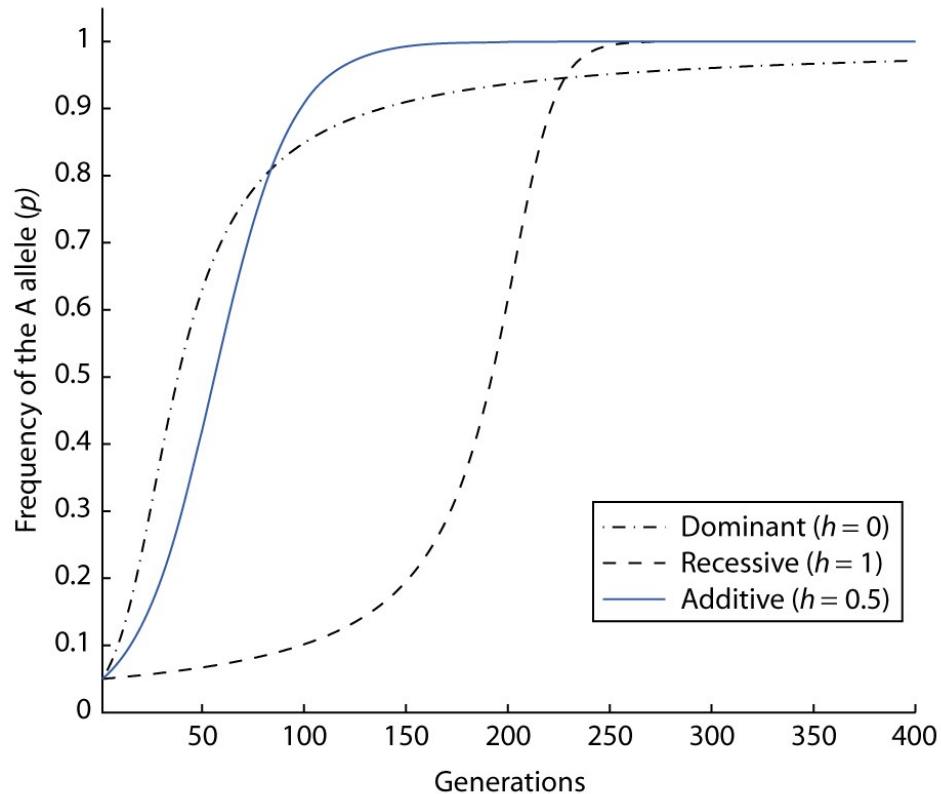


Negative selection against dominant mutations

- Leads to complete elimination of deleterious mutations from the population.
- Diseases caused by dominant mutations usually appear at post-reproductive age (e.g. Huntington disease).



Positive selection

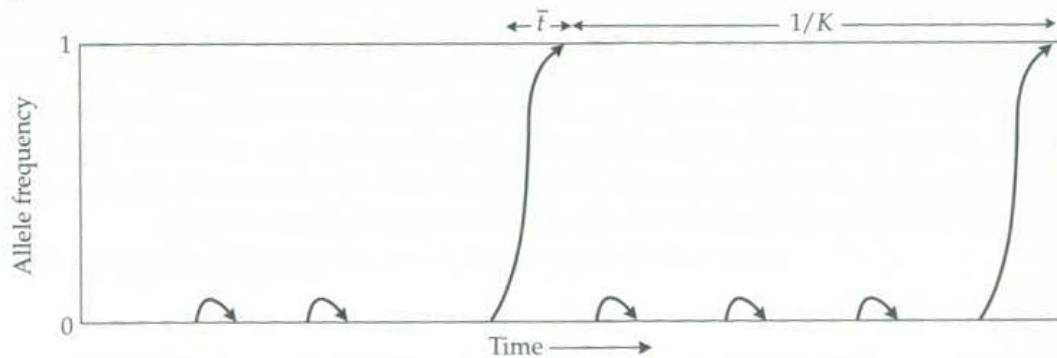


Haldane's sieve.

Dominant advantageous alleles are more likely to fix in the population than recessive alleles.

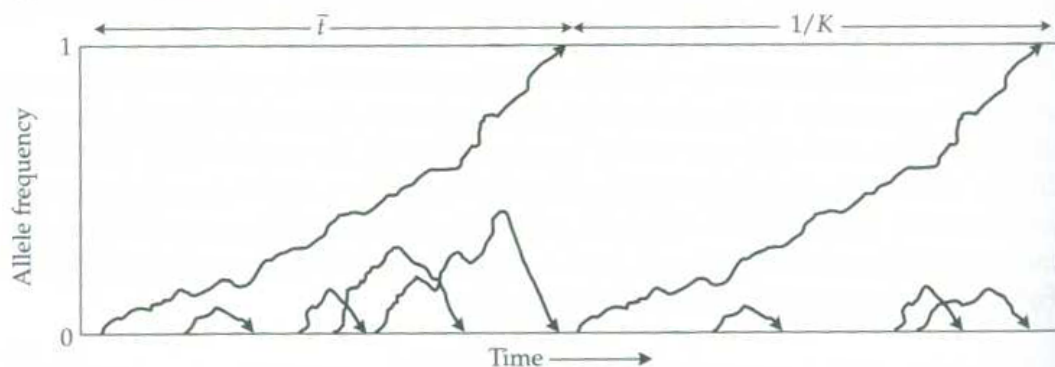
Time to fixation of beneficial mutation

(a) Advantageous mutations



Advantageous mutation
 $t = 2\ln(2N_e)/s$ generations

(b) Neutral mutations



Neutral mutation
 $t = 4N_e$ generations

What is the time to fixation of neutral mutation in human population? Generation time 25 years. N_e 10 000.

$$t = 4N_e \text{ generations}$$

$$t = 4 \cdot 10.000 \text{ generations}$$

$$t = 40.000 \cdot 25 = 1.000.000 \text{ years}$$

What is the time to fixation of beneficial mutation ($s = 5\%$) in human population?

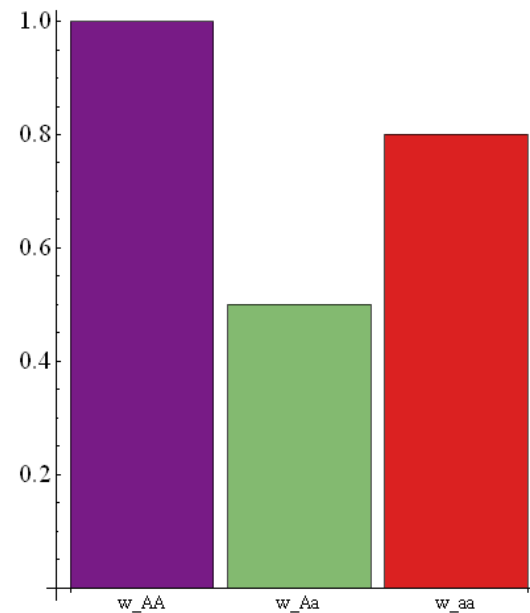
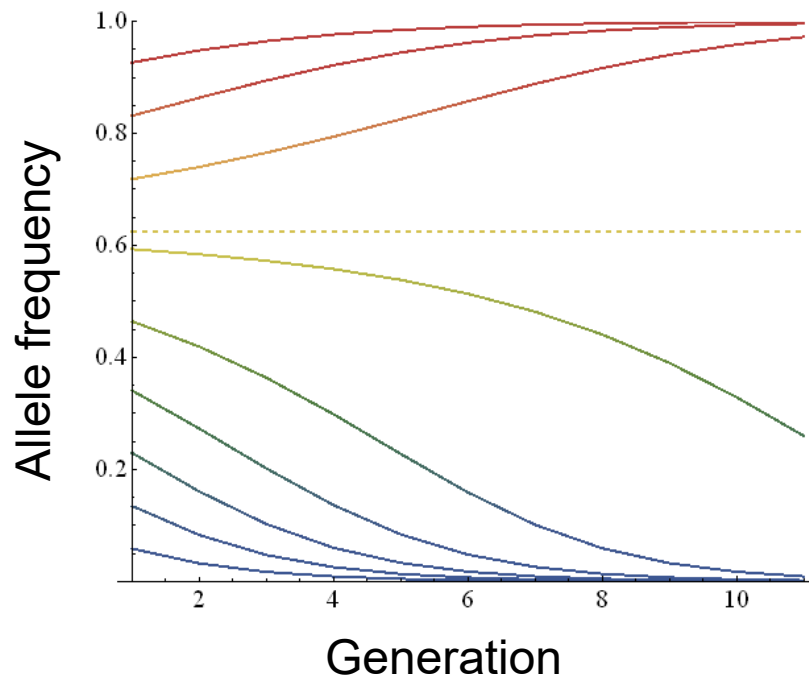
$$t = 2\ln(2N_e)/s \text{ generations}$$

$$t = (2 \cdot 9,9) / 0.05 = 396 \text{ generations}$$

$$t = 396 \cdot 25 = 9.900 \text{ years}$$

Selection against heterozygotes (underdominance)

- Leads to fixation of one or the other allele depending on their frequency in the population and fitness of homozygote genotypes.



Selection against heterozygotes (underdominance)

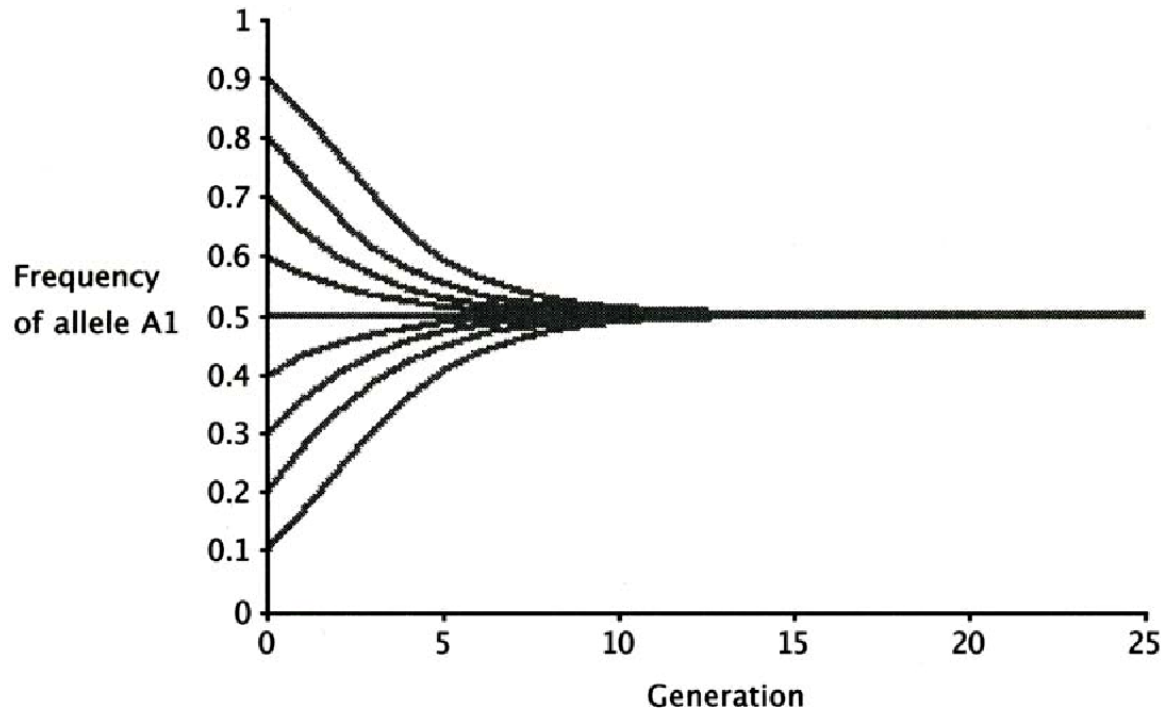


Pseudacraea eurytus

Bateson mimicry

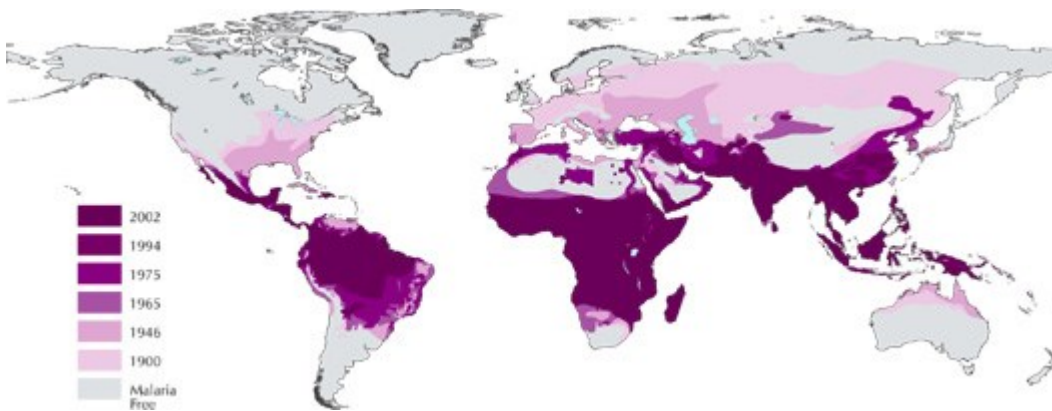
Selection in favor of heterozygotes (overdominance)

- Long-term maintenance of polymorphism in the population.
- If the fitness of homozygotes (AA and aa) is the same, frequency of the two alleles will be also the same (highest frequency of heterozygotes).



Sickle cell anemia and malaria.

- Caused by recessive mutation in the β -globin gene. Recessive homozygotes suffer from anemia, high mortality. Heterozygotes do not have symptoms and are resistant against malaria.



Distribuce malárie 1900 - 2002

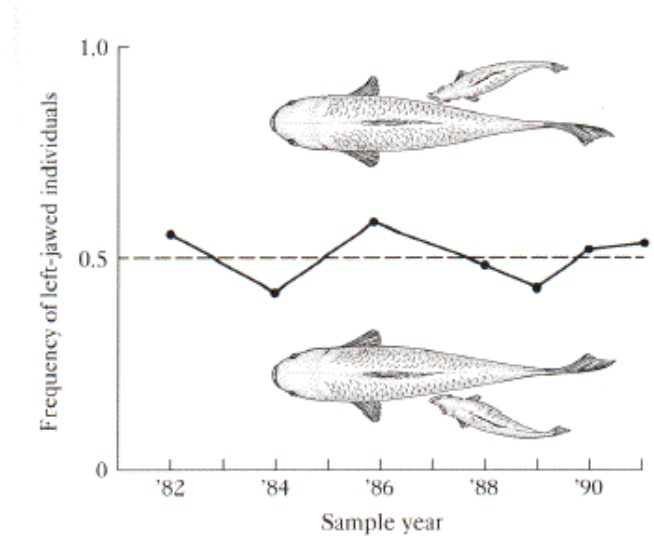


Balancing selection

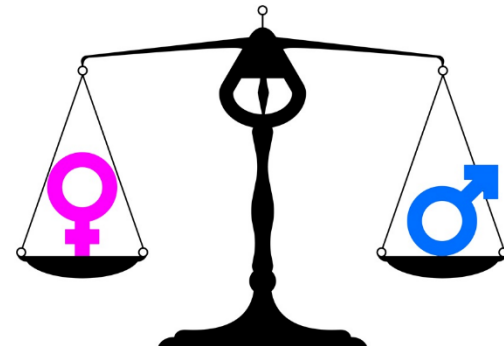
- Selection in favor of heterozygotes
- **Frequency dependent selection**
- Cyclical selection



Red crossbill (*Loxia curvirostra*)



Cichlids (*Perissodus microlepis*)



Sex ratio 1:1