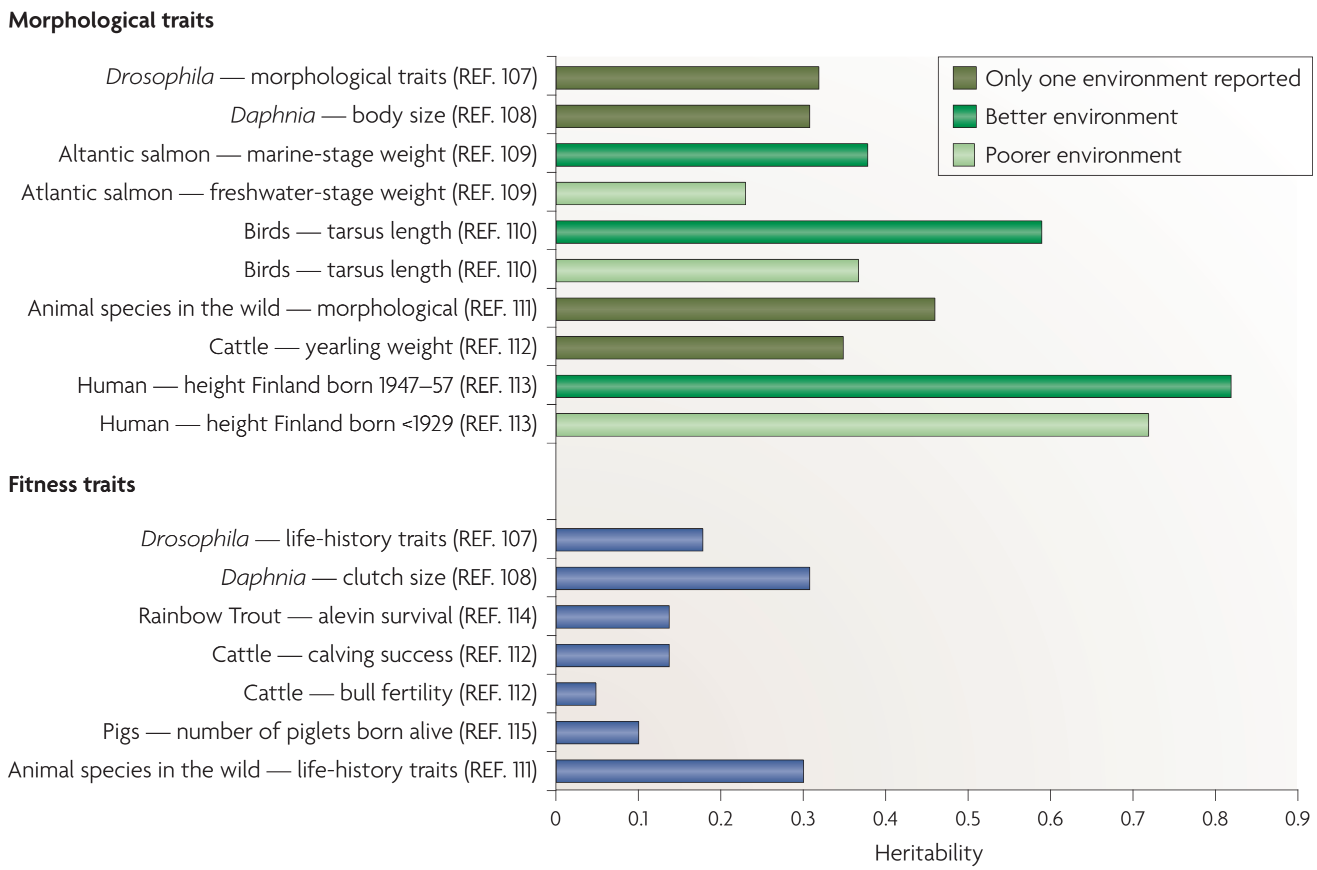
Most traits show h^2 between 0.1 -- 0.9



- Easy to confuse genetic inheritance with shared environment
- Heritability measures are environment specific

- Differences between populations in a highly heritable phenotype, do not mean that the differences between populations are genetic.

- South Korean men 1.738 m (5 ft 8.5 in)
- North Korean men 1.65m (5 ft 5 in)

- English men mid-19th C. 1.66 m (5 ft 5.5 in)
- English men today. 1.772 m (5 ft 10 in)

Confusion over population differences in IQ are some bad examples of this

"…Owing to this struggle for life, any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, in its infinitely complex relations to other organic beings and to external nature, will tend to the preservation of that individual, and will generally be inherited by its offspring. The offspring, also, will thus have a better chance of surviving, for, of the many individuals of any species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection…"

Charles Darwin, "The Origin of Species"

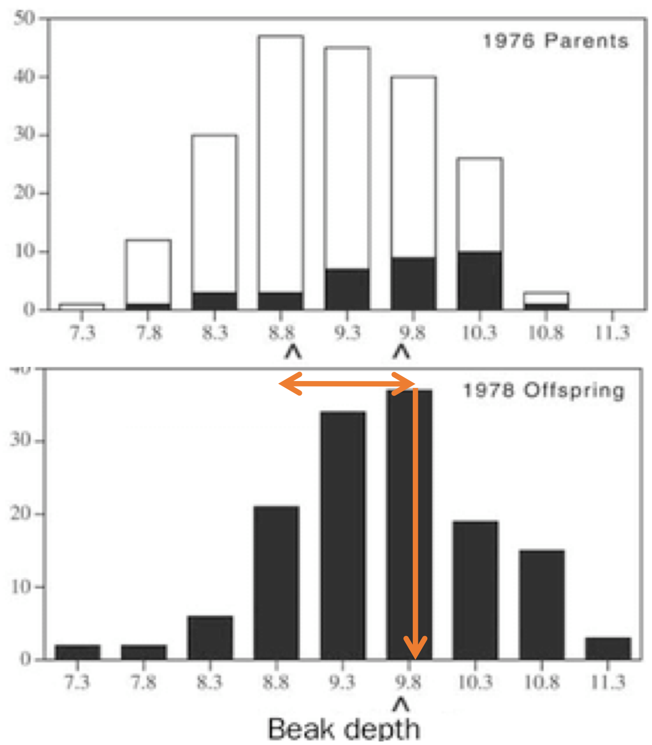
Conditions for evolution by natural selection

1. Variation must be present

2. This variation must affect the probability of survival and reproduction (fitness)

3. This variation must be heritable, i.e. genetic

- Evolution by natural selection will only occur if the change in mean phenotype caused by selection can be transmitted to next generation (i.e. it is heritable).

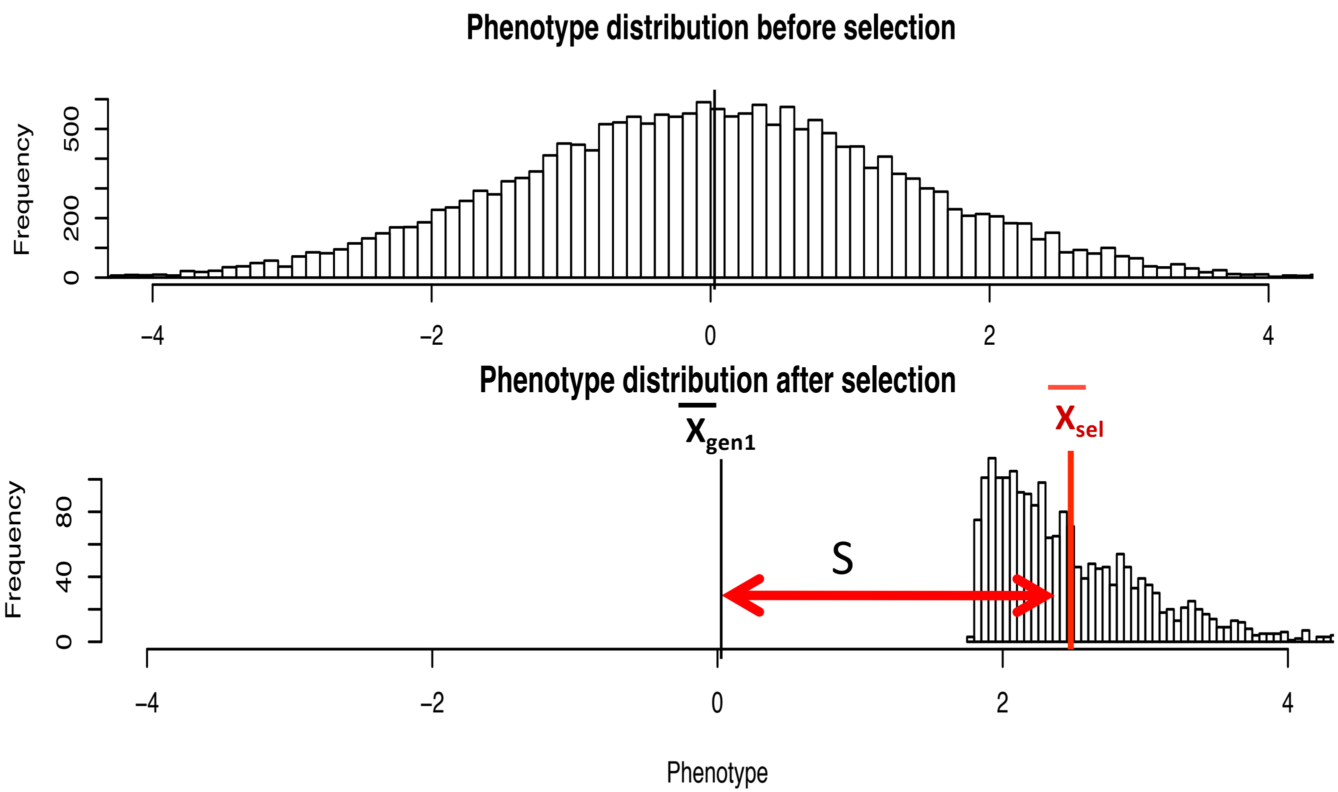


•Natural selection can act on a trait even in absence of genetic variation in that trait.

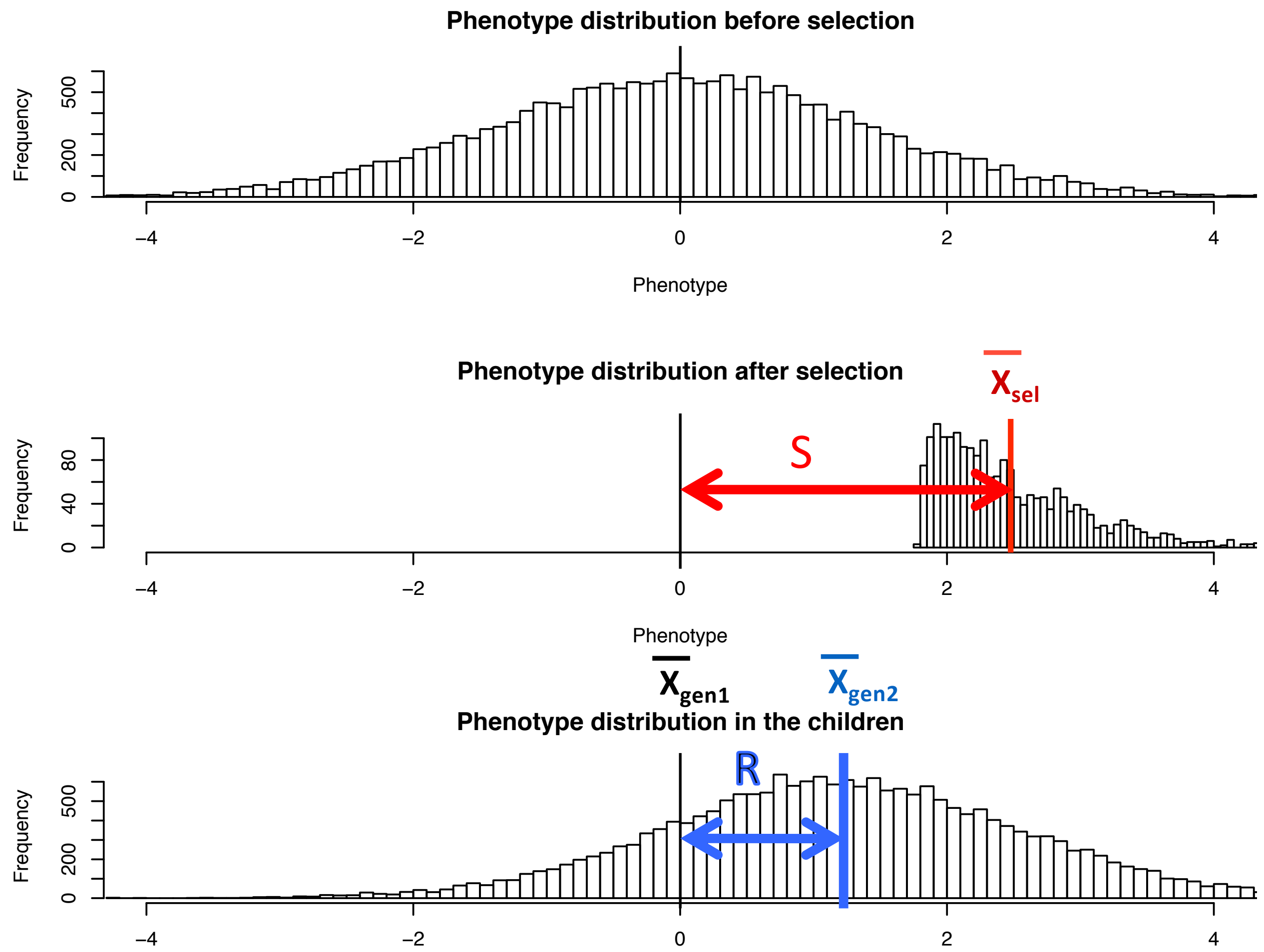
•However, <u>no</u> evolution due to natural selection will occur without genetic variation.

S, the selection differential, is the difference caused by selection in mean phenotype within a generation

$$= \bar{X}_{sel} - \bar{X}_{gen1}$$



R, the selection response, is the change in the trait mean across successive generations $= \bar{X}_{gen2} - \bar{X}_{gen1}$



The breeder's equation.

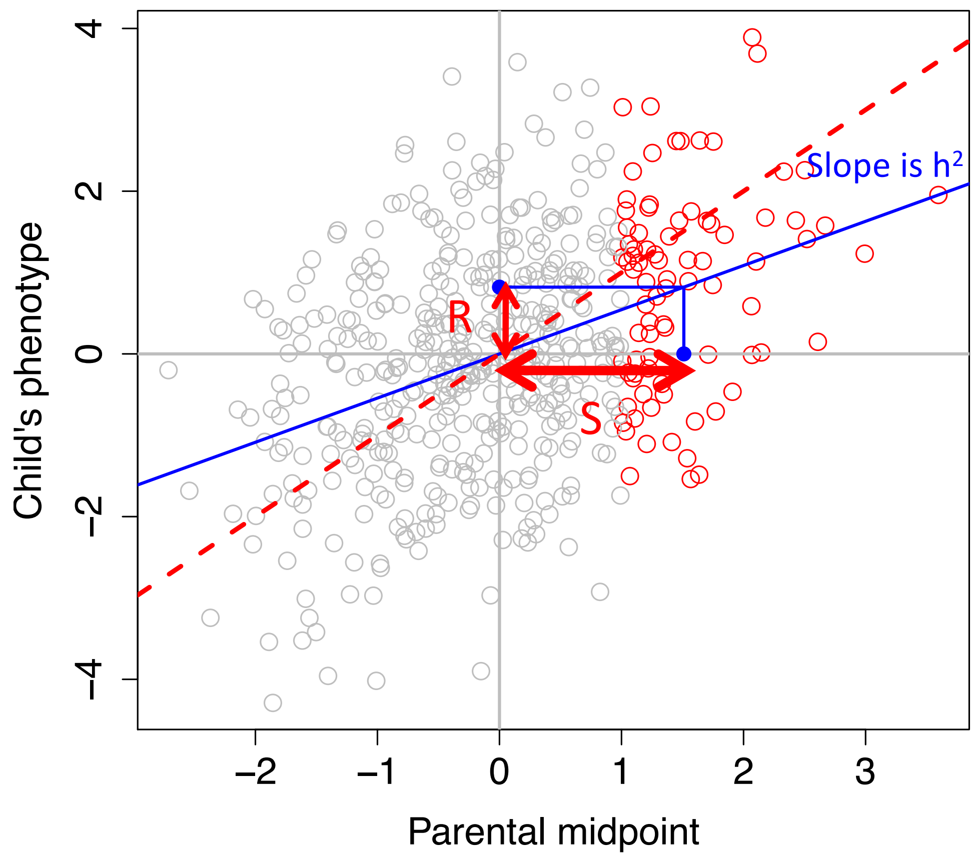
$$R = h^2 S$$

S – change in phenotypic mean in parental generation due to selection

R- Response: change in mean in offspring generation

h^2- Narrow sense heritability,

Rapid evolution
With strong selection pressures
Highly heritable traits.



The breeder's equation.

$$R = h^2 S$$

Mean flowering time before selection: 60 days

Selection due to drought in one generation moved the mean flowering time to 53 days

$S = -7$ days

$h^2 = 0.46$

$R = 0.46 \times (-7) = -3.22$ days.

Predicted change in next generation.

Mustard weed

PNAS

Rapid evolution of flowering time by an annual plant in response to a climate fluctuation

Steven J. Franks*, Sheina Sim, and Arthur E. Weis

Department of Ecology and Evolutionary Biology, University of California, Irvine, CA 92697

Edited by Barbara A. Schaal, Washington University, St. Louis, MO, and approved November 30, 2006 (received for review September 22, 2006)

Ongoing climate change has affected the ecological dynamics of populations remain unchanged (11). The second protocol in-

The breeder's equation.

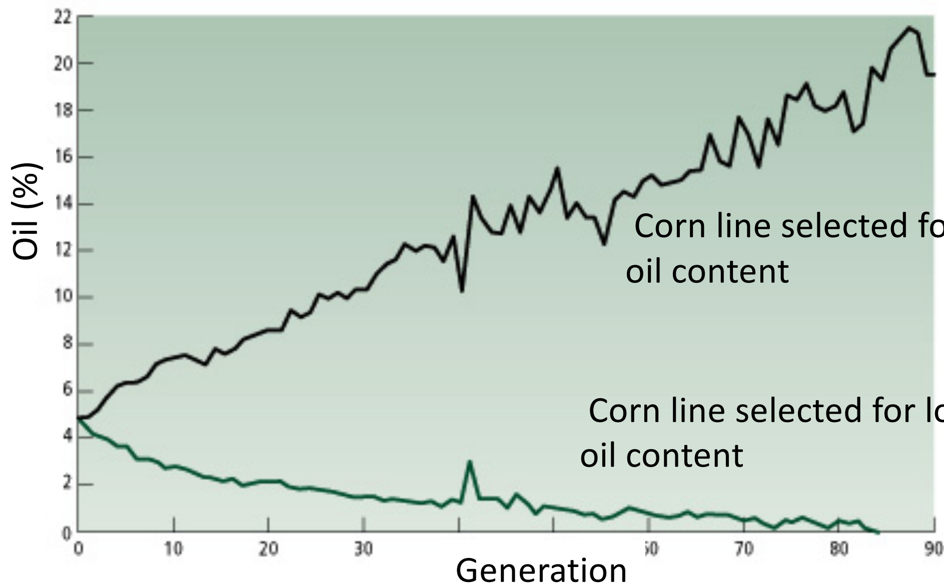
- We can apply the breeder's equation over many generations:
- Change in mean over n discrete generations
- $R_n = n\,h^2\,S$

- If S is a constant each generation
- And h^2 remains constant. *

- *This may be a big if.

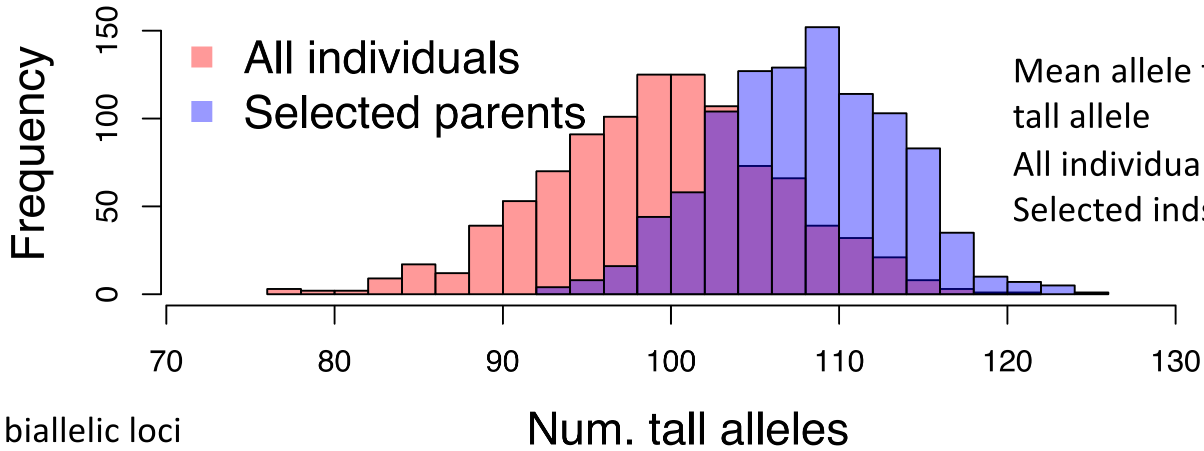
Artificial selection

- Nearly every trait responds rapidly to artificial selection in domesticated species and in the lab.



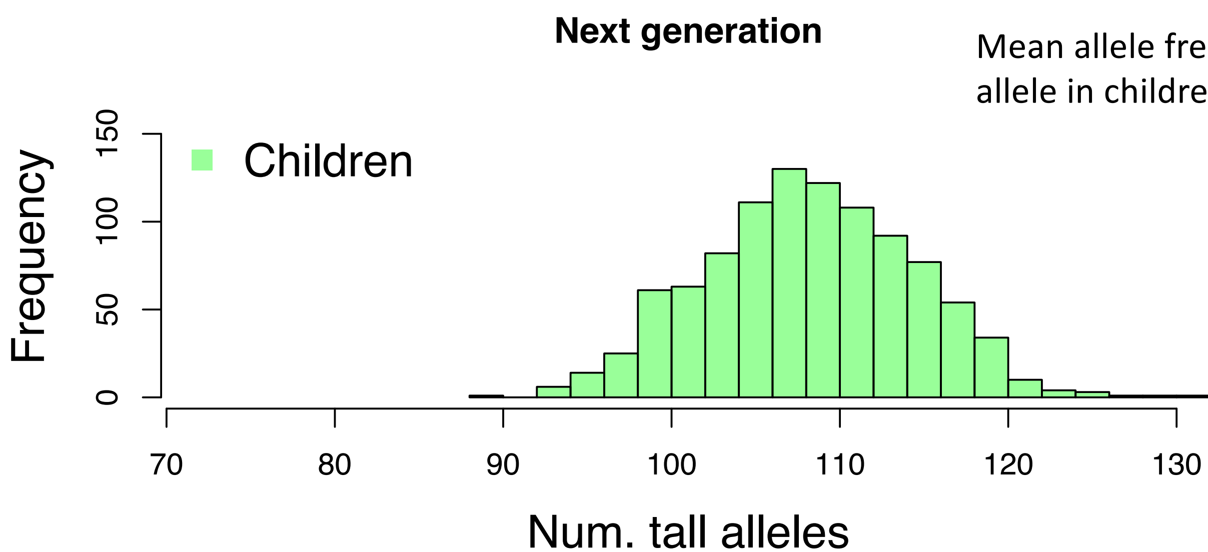
Ridley Book

- Thus there is abundant genetic variation in almost every trait, on which selection can easily act.



Mean allele freq. of tall allele
All individuals =0.5
Selected inds = 0.54

100 biallelic loci



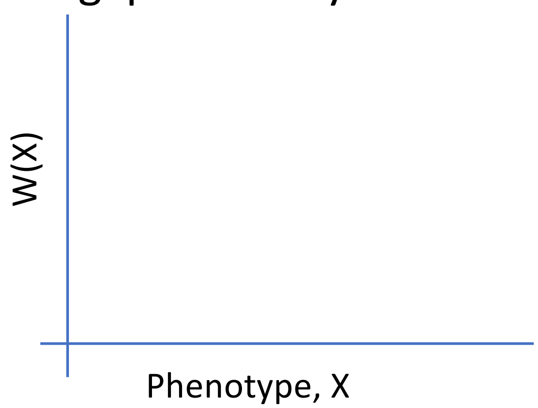
Mean allele freq. of tall allele in children =0.54

Fitness

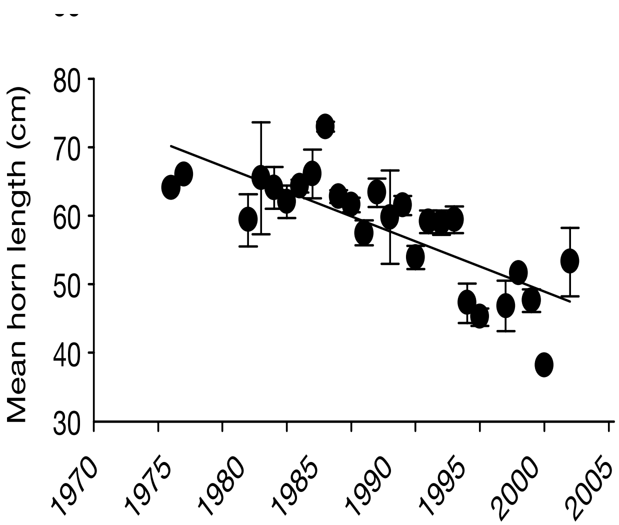
fitness=an individual's **expected** number of offspring left to the next generation in specific to the environmental and ecological circumstances

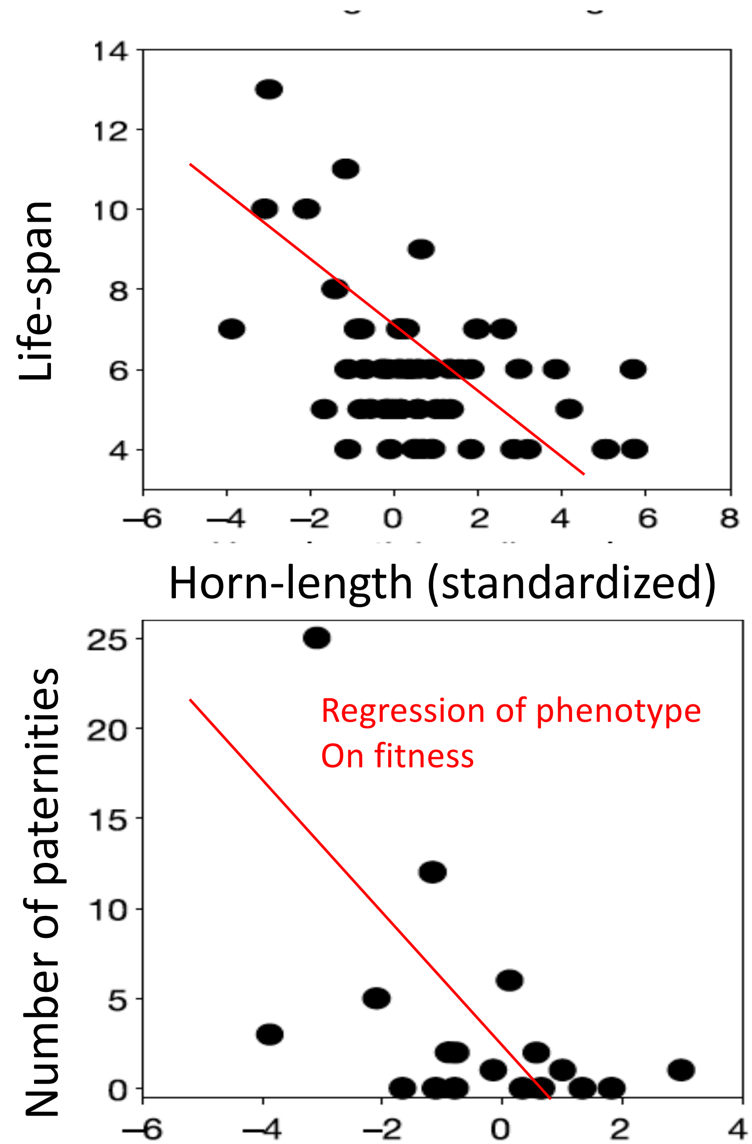
Fitness of individuals with a particular phenotype.

W(X) = Fitness of individuals with phenotype X,
e.g. probability of surviving to reproduce

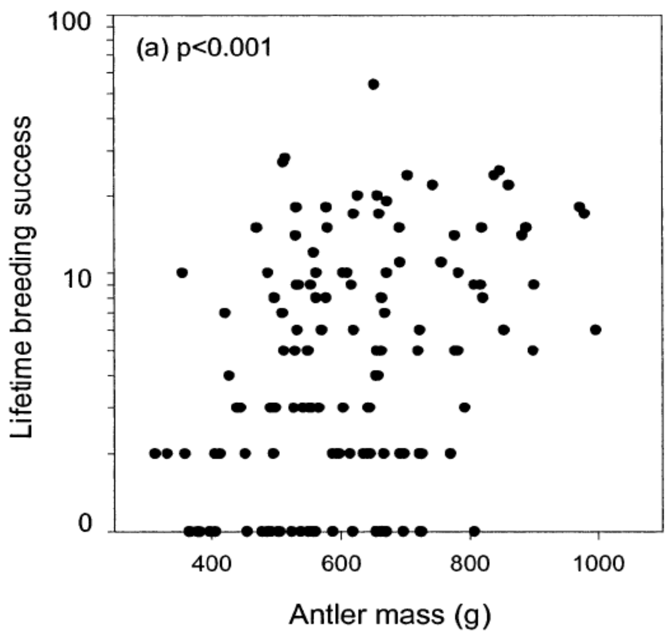


Natural selection= non-random variation in fitness across individuals who differ in phenotype.

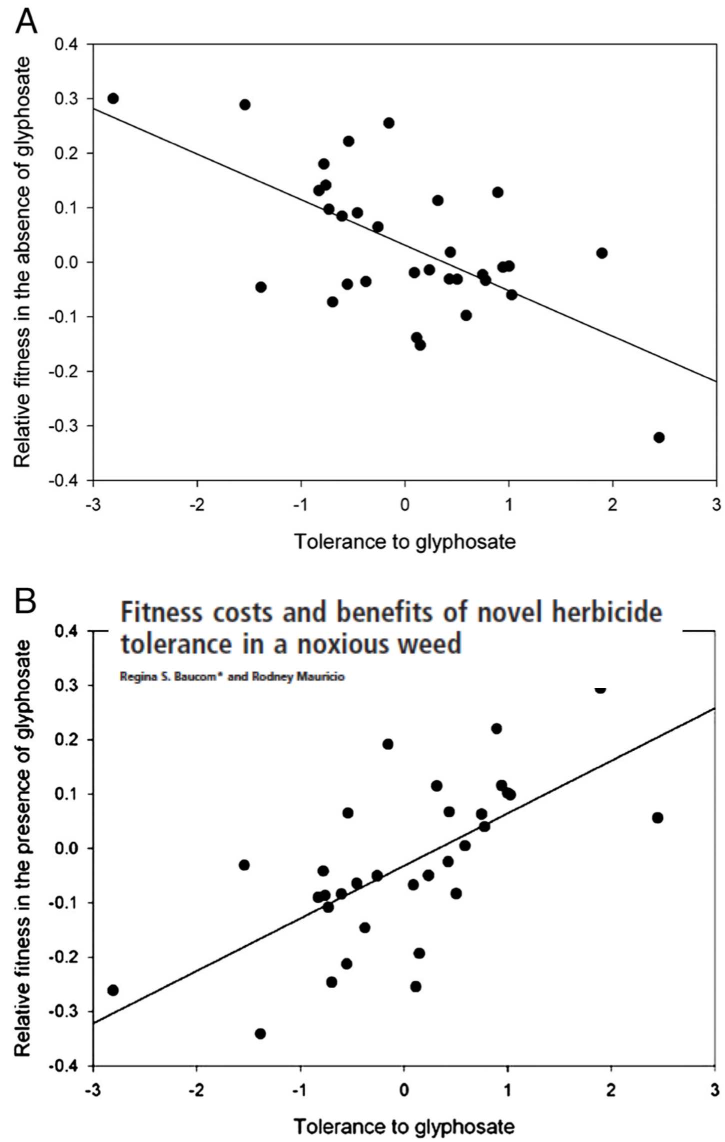

Mean horn length (cm)
80
70
60
50
40
30
1970
1975
1980
1985
1990
1995
2000
2005

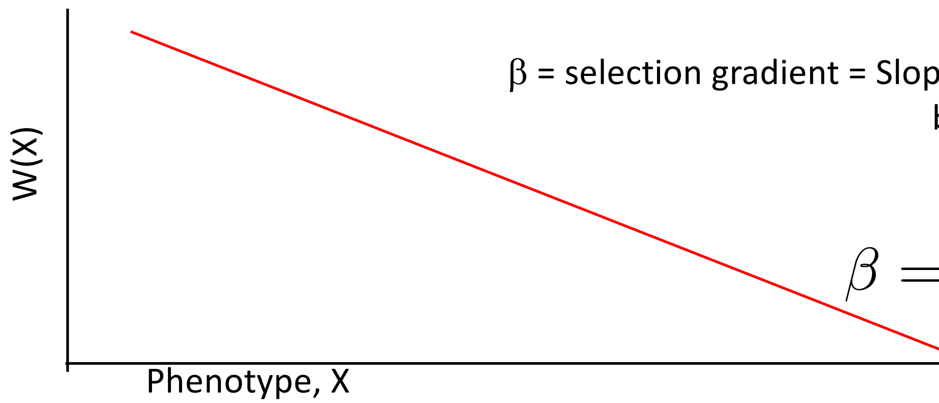

Life-span
14
12
10
8
6
4
−6
−4
−2
0
2
4
6
8
Horn-length (standardized)
Number of paternities
25
20
15
10
5
0
Regression of phenotype
On fitness
−6
−4
−2
0
2
4

E.g. strong selection gradient
on male antler size in red deer



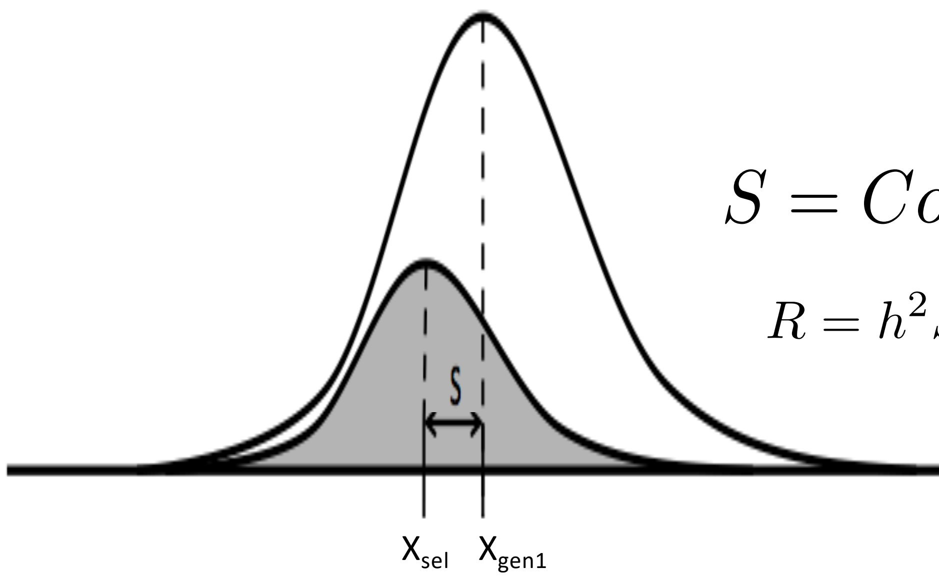
Kruuk et al 2002, Evolution





β = selection gradient = Slope of regression between fitness and phenotype

$$\beta = \frac{Cov(W(X), X)}{V_P}$$



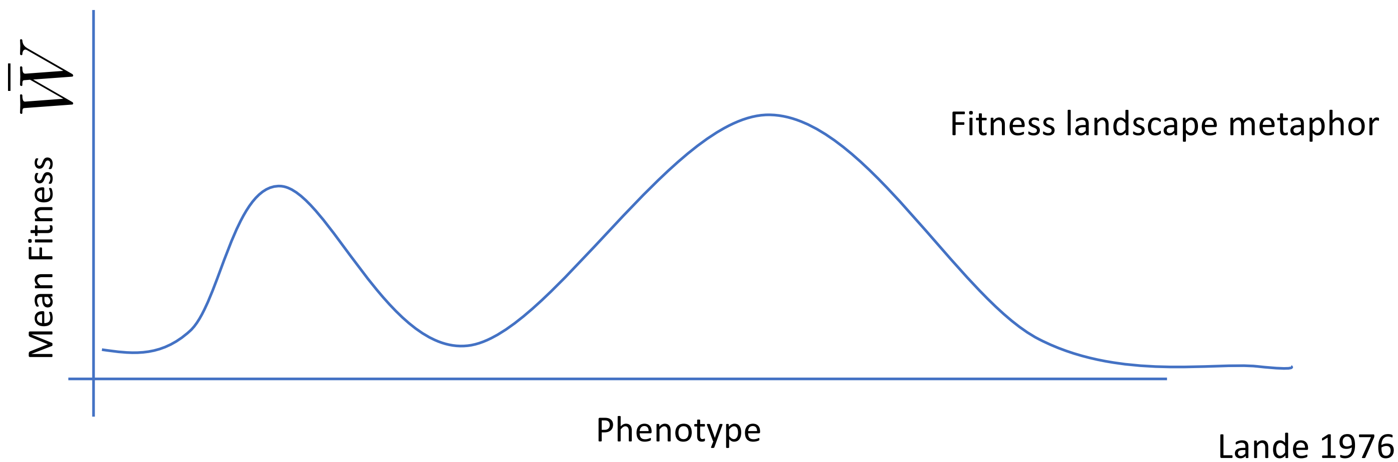
$$S = Cov(W(X), X)$$

$$R = h^2 S = \frac{V_A}{V_P} S = V_A \beta$$

P(X) = Fraction of individuals with Phenotype X before selection

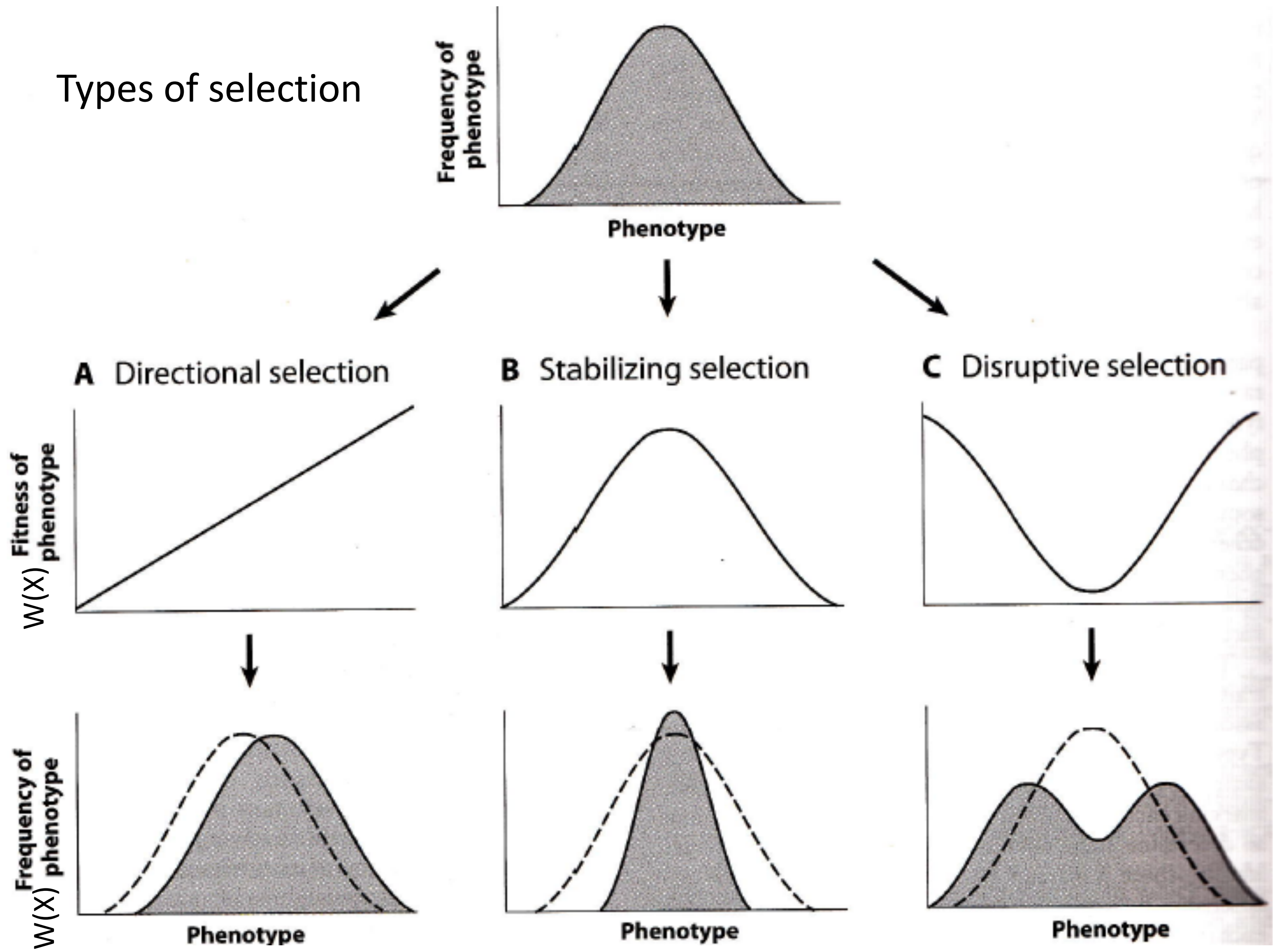
Mean fitness of the Population = $\bar{W} = \int W(X)P(X)dX$

$$R = \frac{V_A}{\bar{W}}\frac{d\bar{W}}{dX}$$

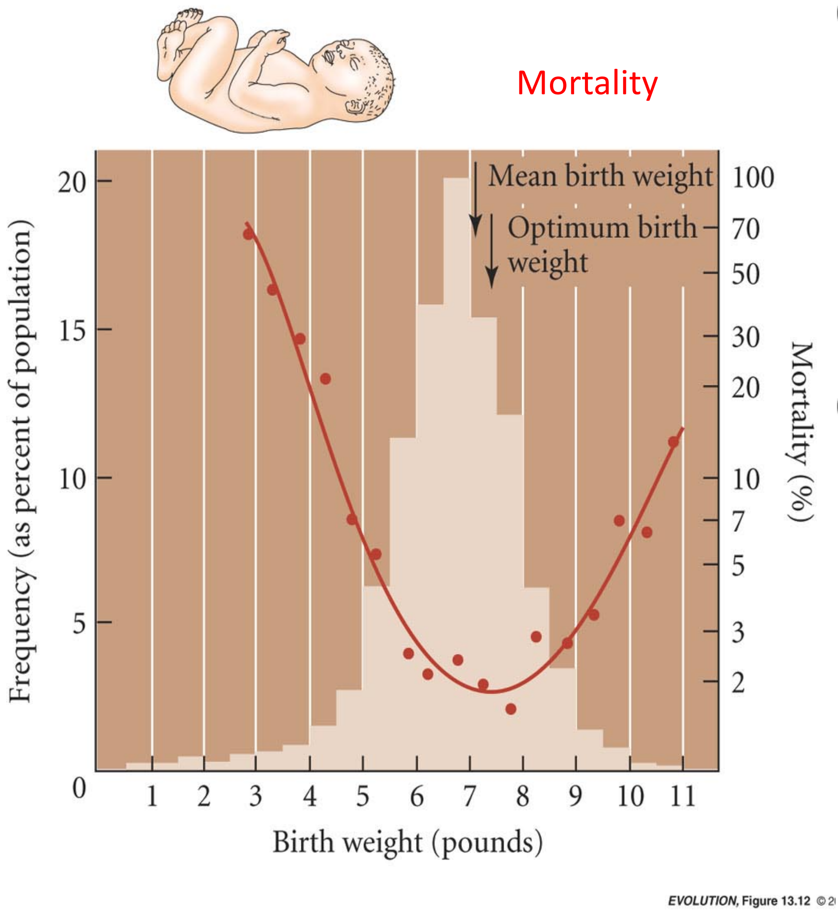


Lande 1976

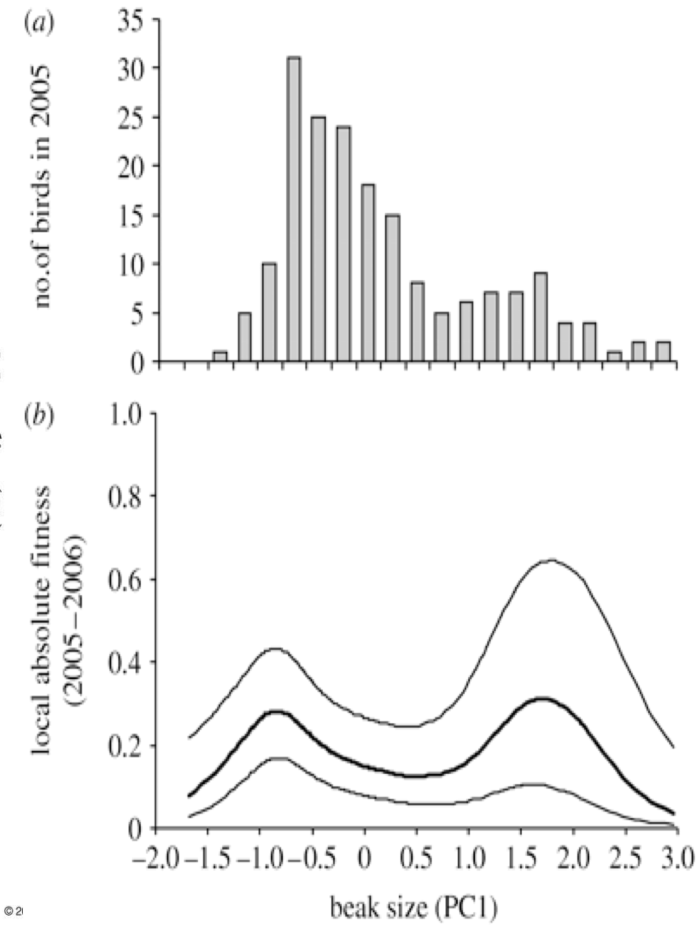
Types of selection



Birth weight in humans:
A classic case of stabilizing selection



Disruptive selection in a population of Darwin's Finches



Trade-offs

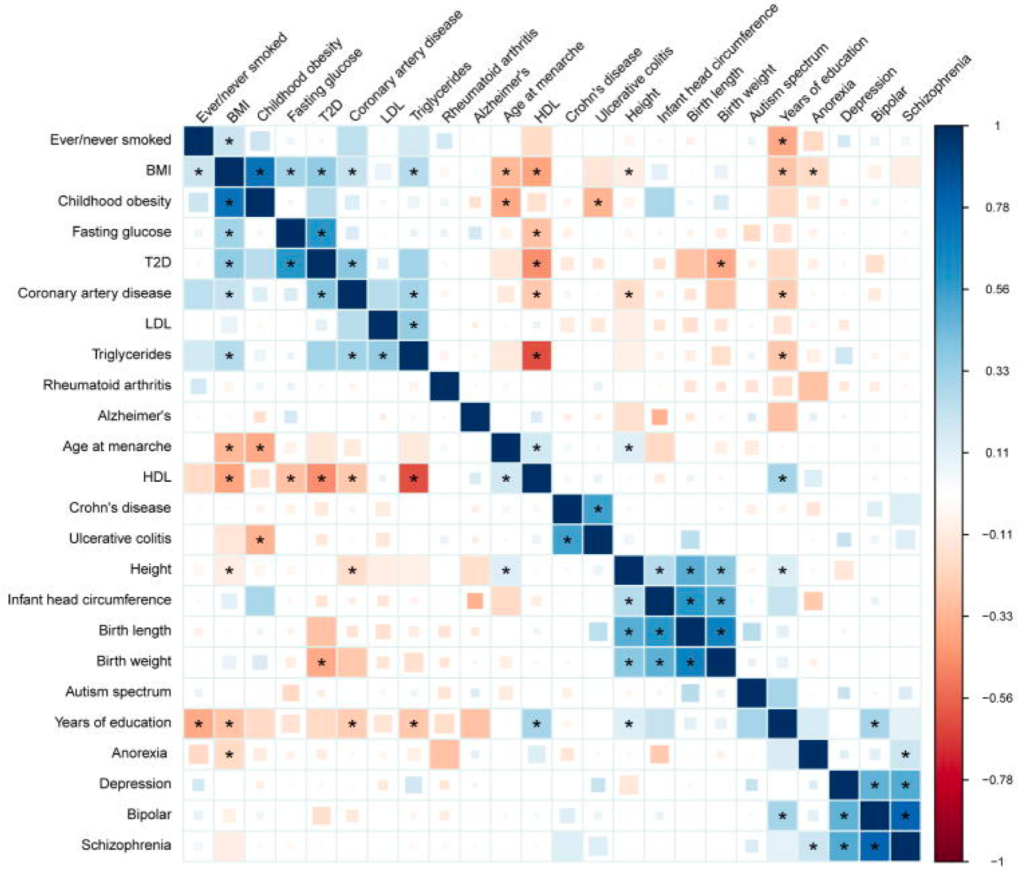
- Why isn't every organism as fast, efficient, attractive as they can be?
- Constraints.
- Evolution is full of trade-offs
  - Given a limited set of resources you have to allocate them.
  - How populations of organisms adapt to these trade-offs, in the face of differences in ecology & environment, generate differences in life histories.

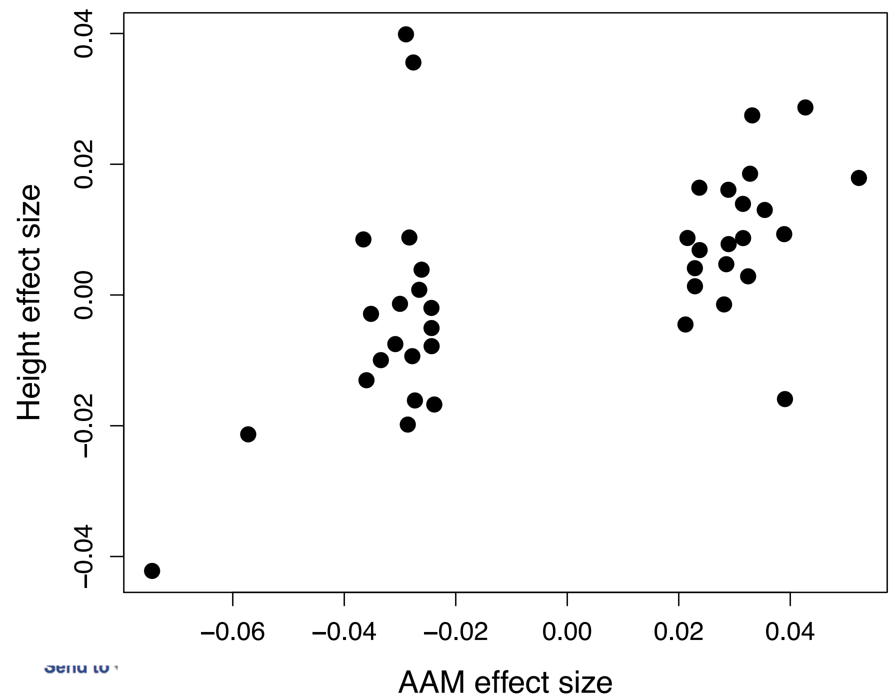
Correlated evolution of Quantitative traits
Through Natural Selection

Genetic correlation

The genetic basis of variation in a phenotype is never independent of some other phenotypes.

Most tradeoffs can be thought of in terms these correlations.





Nat Genet. 2015 Nov;47(11):1236-41. doi: 10.1038/ng.3406. Epub 2015 Sep 28.

An atlas of genetic correlations across human diseases and traits.

Bulik-Sullivan B[1,2,3], Finucane HK[4], Anttila V[1,2,3], Gusev A[5,6], Day FR[7], Loh PR[1,5]; ReproGen Consortium; Psychiatric Genomics Consortium; Genetic Consortium for Anorexia Nervosa of the Wellcome Trust Case Control Consortium 3, Duncan L[1,2,3], Perry JR[7], Patterson N[1], Robinson EB[1,2,3], Daly MJ[1,2,3], Price AL[1,5,6], Neale BM[1,2,3].

Genetic correlations

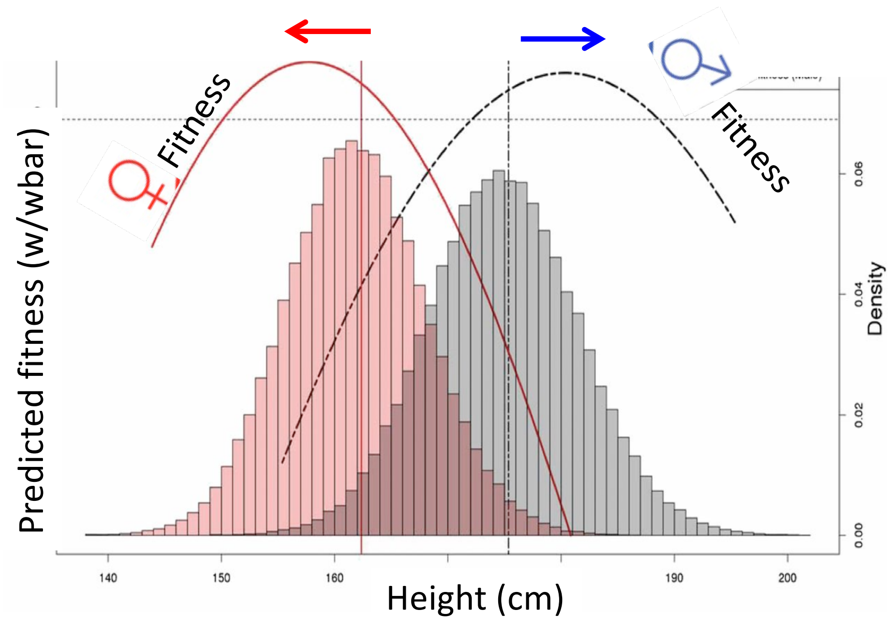
Some pleiotropic effects are more complicated and require a much deep understanding of the organism and/or development/molecular biology of the changes involved.

Also genetic correlations can be driven by linkage:
Alleles responsible for different traits can be physically linked on a chromosome.

(Also by assortative mating)

--Thus the genetic variance of traits is often partially shared.
i.e. the genetic covariance of traits is often not zero.

sexually antagonistic pleiotropy



+ve genetic corr. between sexes inhibits optimum solution for both sexes

Evidence of directional and stabilizing selection in contemporary humans

Jaleal S. Sanjak, Julia Sidorenko, Matthew R. Robinson, Kevin R. Thornton, and Peter M. Visscher