

R.A. Fisher (1918)

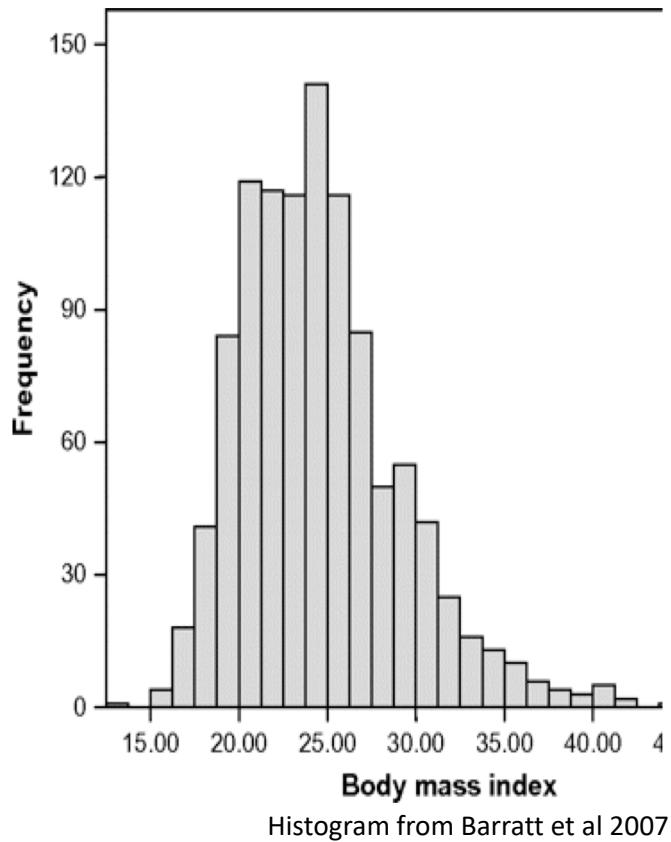
"The correlations between relatives on the supposition of Mendelian inheritance"

- Reconciled these two views by showing that the mendelian inheritance of many alleles, each of small effect, gave rise to:
 - Resemblance between relatives.
 - regression towards the mean.

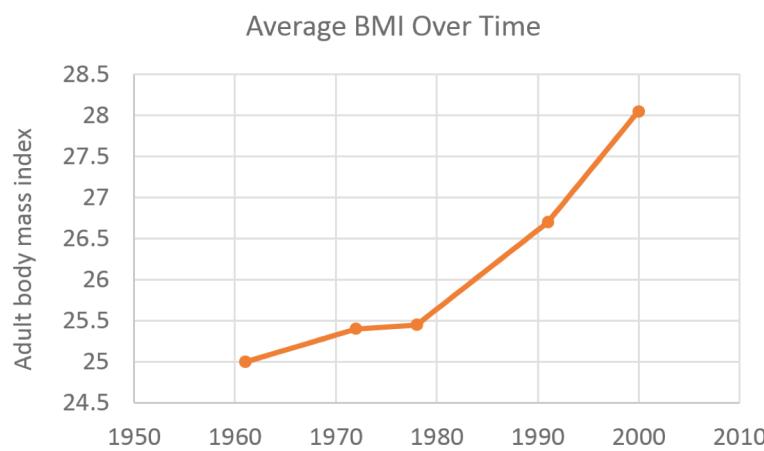


The apparent 'blending' of traits is due to inheritance $\frac{1}{2}$ alleles from Mum and $\frac{1}{2}$ from Dad.

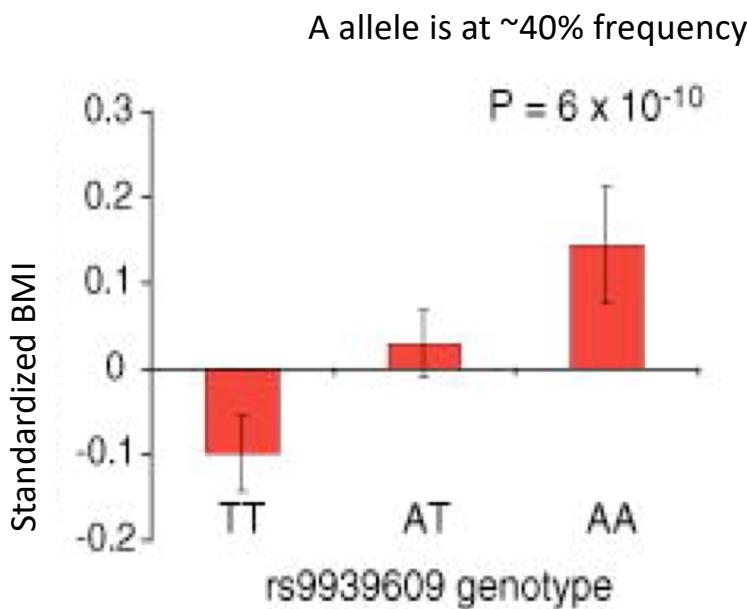
To what extent is my weight genetic?



My height ~6 foot
My weight ~160 pounds
My BMI 21.7



Phenotypes are always due to the interaction of genes and environments.



A Common Variant in the *FTO* Gene Is Associated with Body Mass Index and Predisposes to Childhood and Adult Obesity

Timothy M. Frayling,^{1,2*} Nicholas J. Timpson,^{3,4*} Michael N. Weedon,^{1,2*} Eleftheria Zeggini,^{3,5*}

My BMI is 22.4

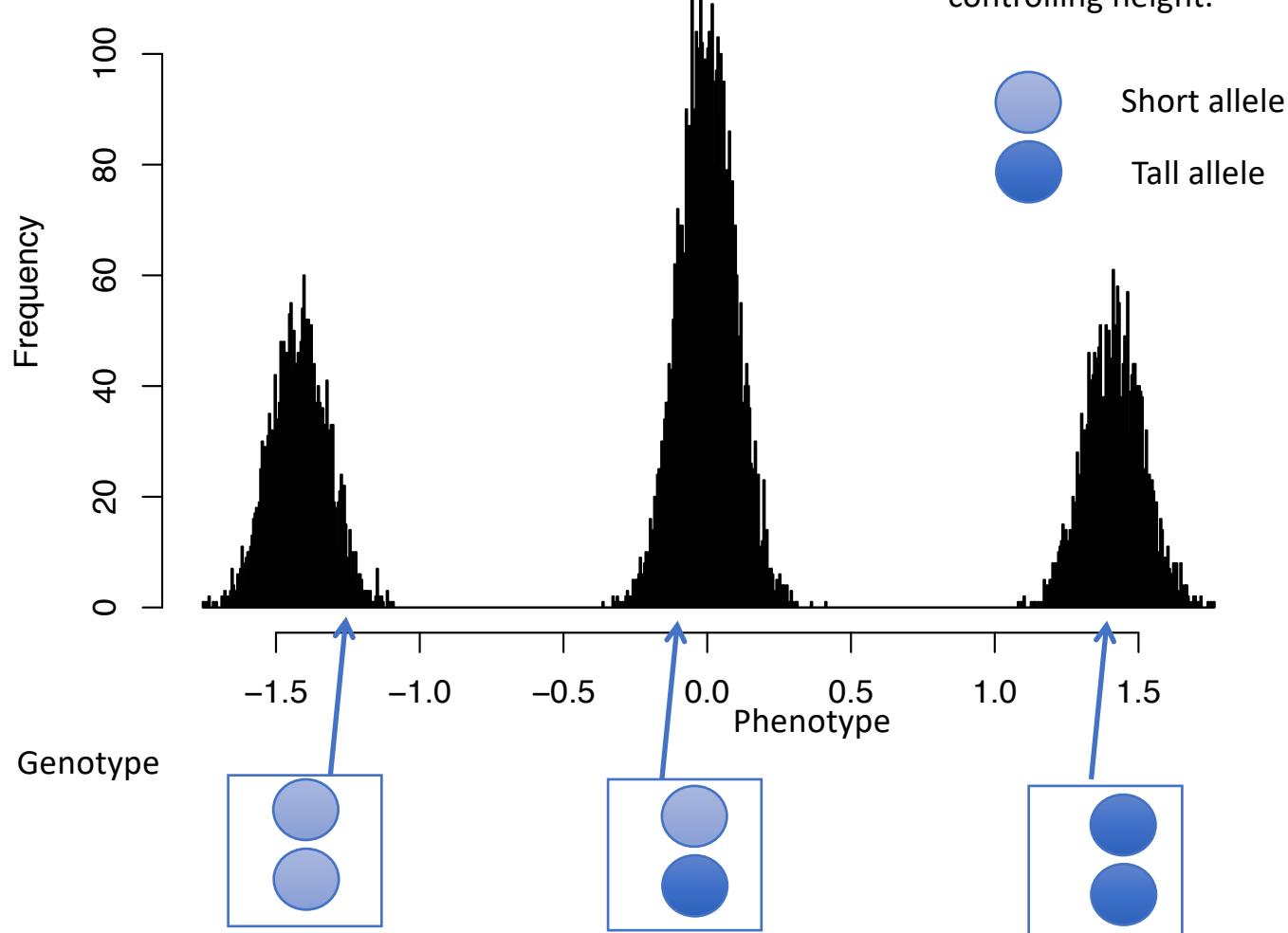
Top 6 Alleles associated with BMI:

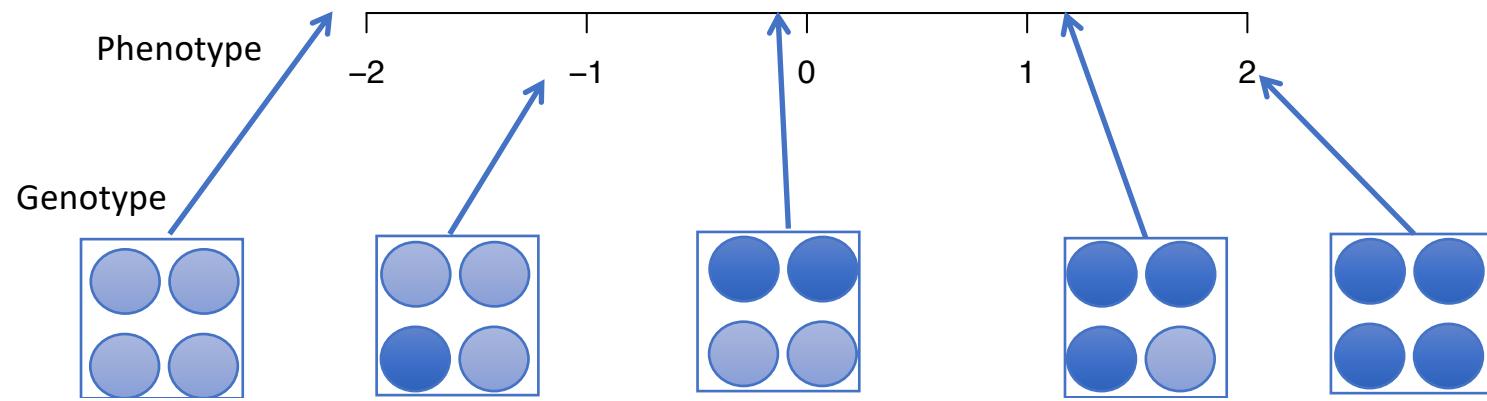
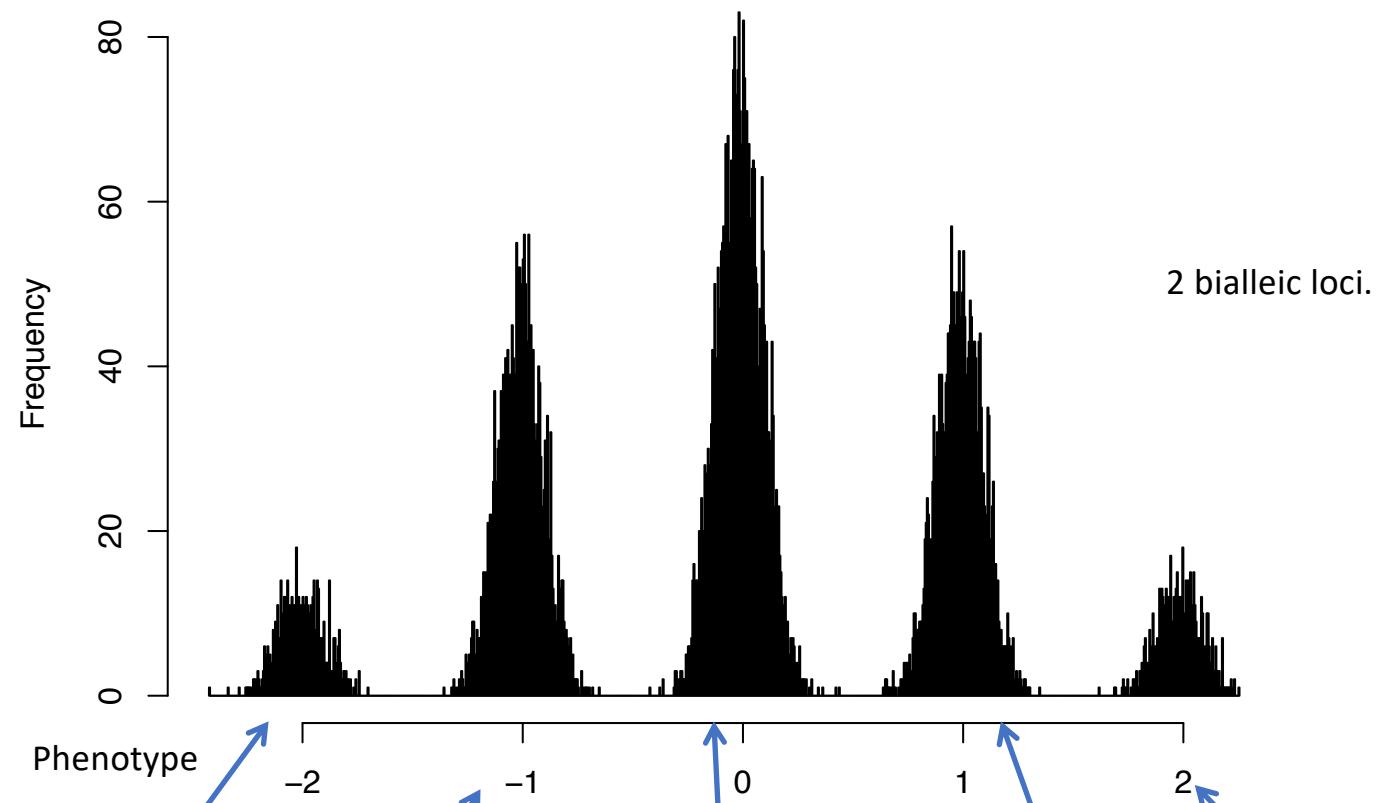
SNP name	My Genotype	Avg. Effect on BMI*
rs3751812	GT	0.33 for each T
rs10871777	AA	0.2 for each G
rs13130484	CC	0.19 for each T
rs4788102	GG	0.15 for each A
rs10838738	AA	0.07 for each G
rs3101336	CT	0.1 for each C

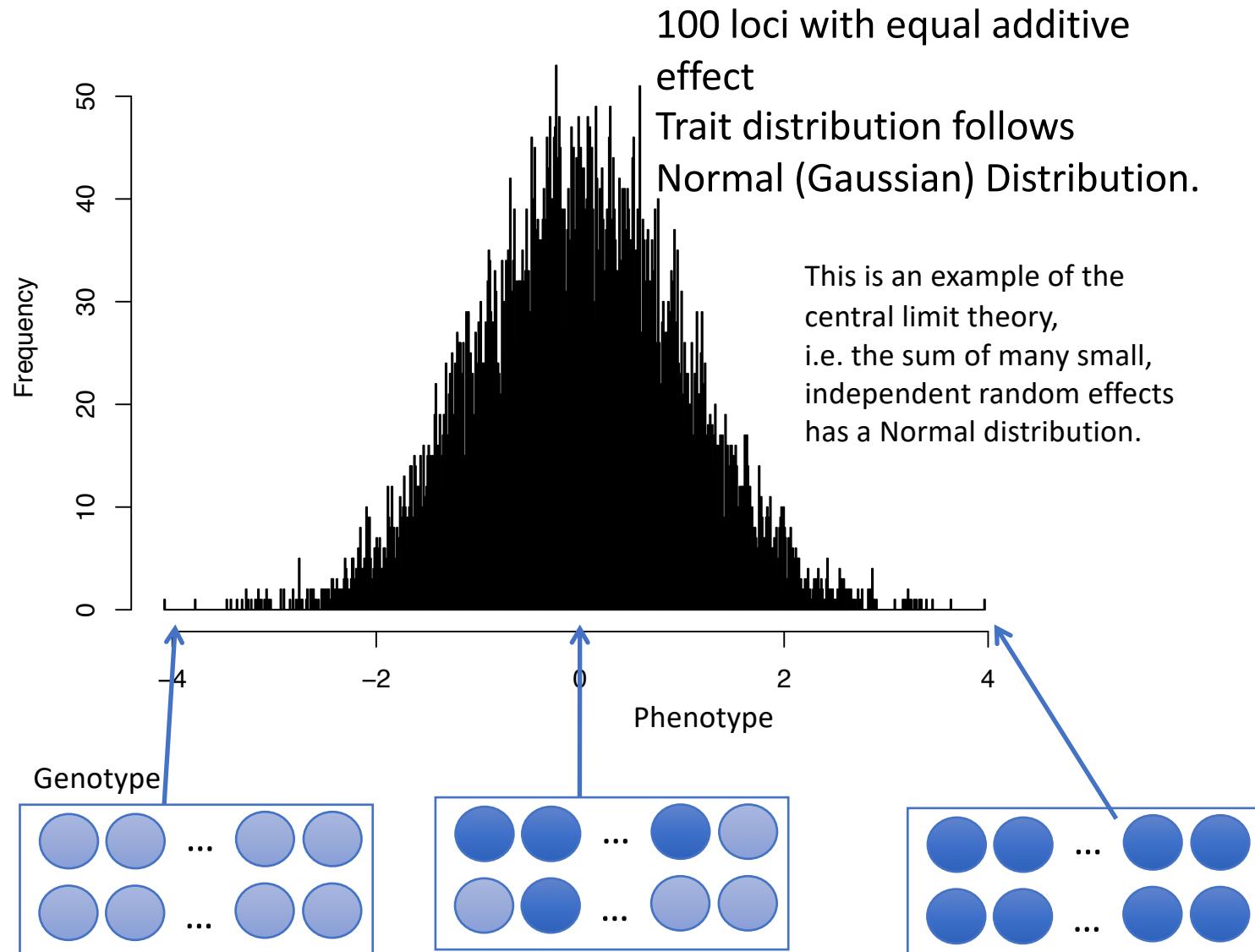
There are many hundreds more genetic variants contributing to BMI.

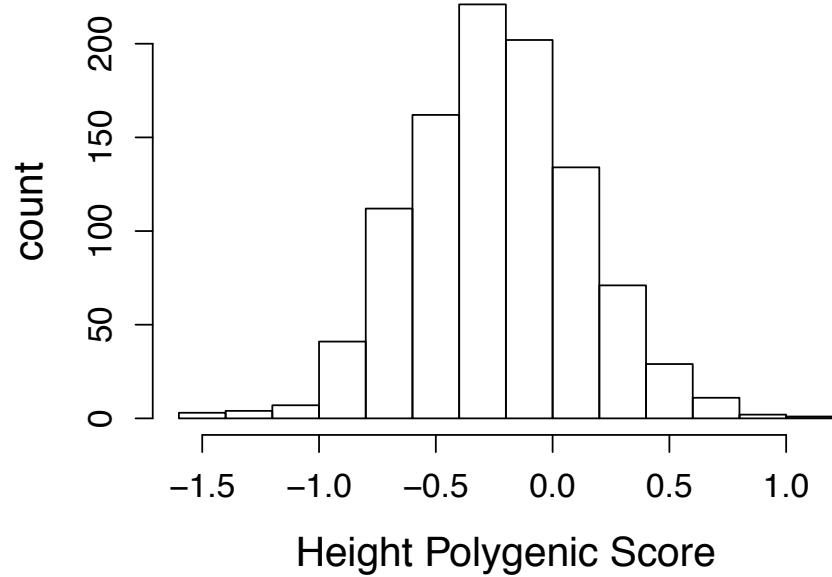
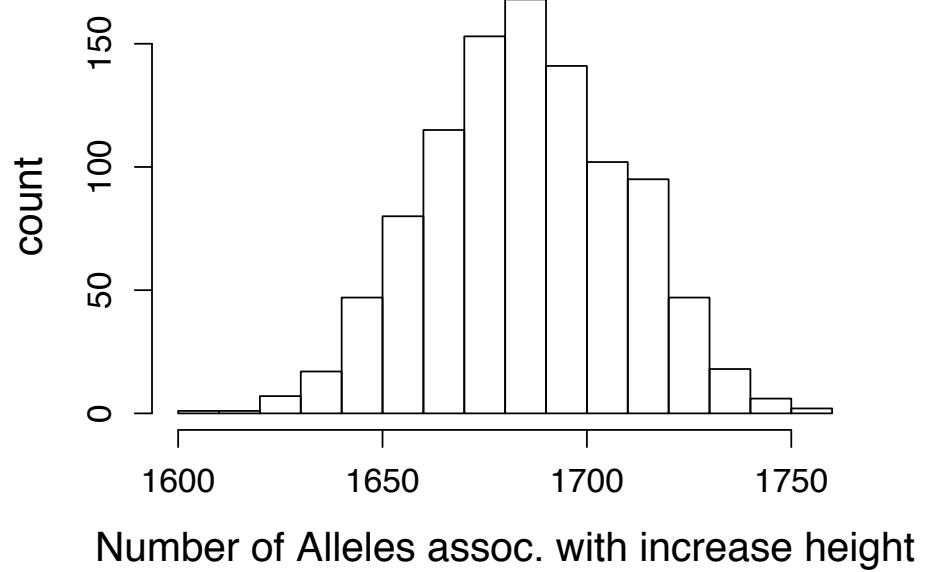
*Calculated by 23&Me.

Two alleles at a single locus controlling height.







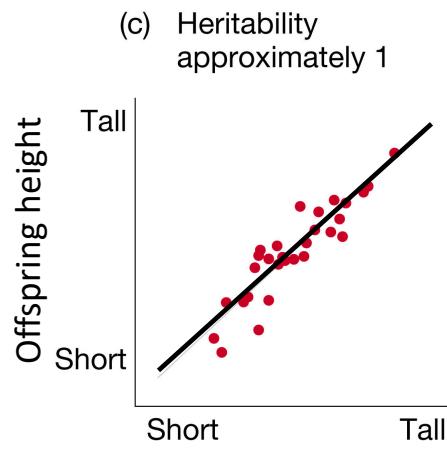


Resemblance between relatives in Quantitative traits

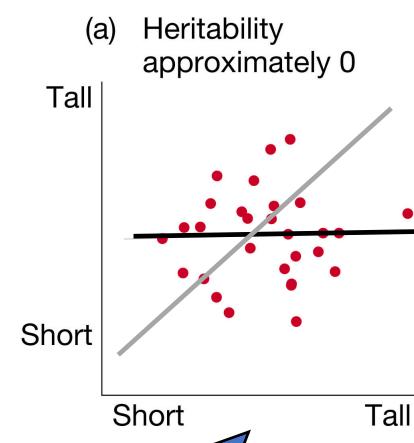
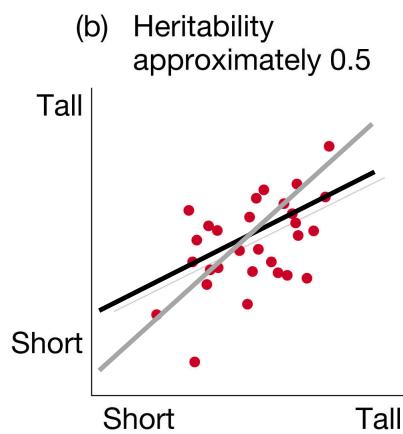
- Individual 1's phenotype = X_1
- Individual 2's phenotype = X_2
- Want to know the $\text{cov}(X_1, X_2)$
- = $\text{Cov}((X_{1M} + X_{1P} + X_{1E}), (X_{2M} + X_{2P} + X_{2E}))$

Heritability is estimated from mid-parent-offspring analysis as the slope of the regression line

$$\text{Slope} = \text{Cov}(X, Y) / \text{Var}(X) = (V_A/2) / (V_P/2) = h^2$$

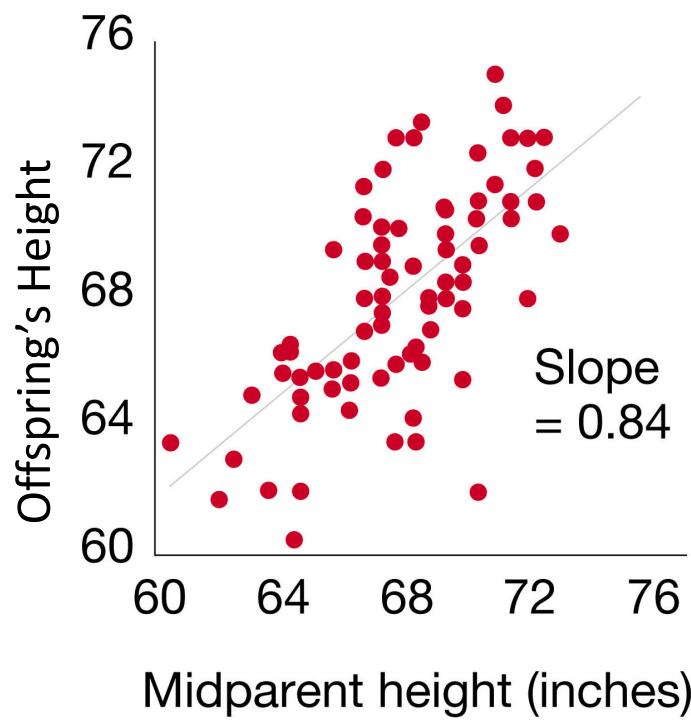


Offspring's phenotype predicted by parental mean

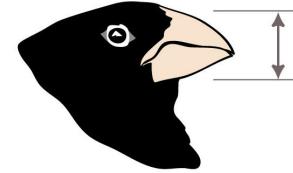
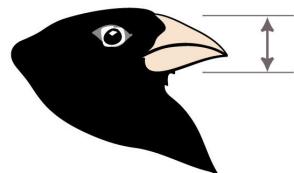
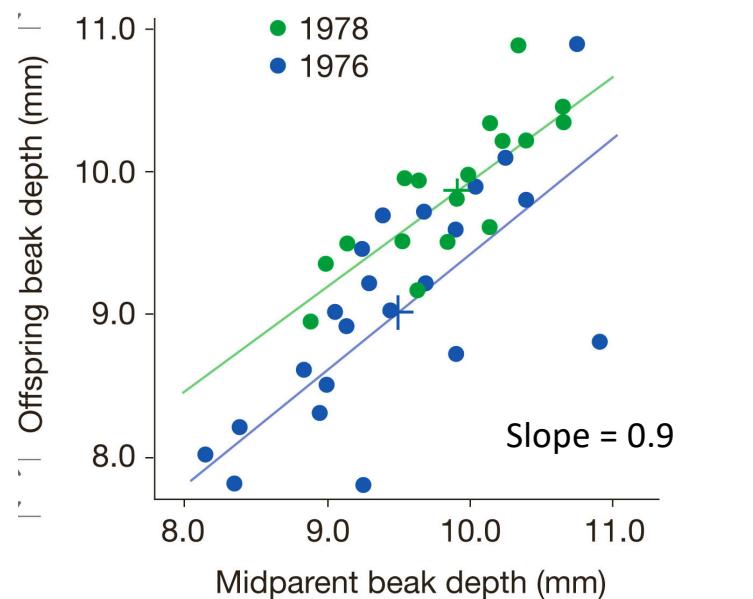


When mid-parental values does not influence offspring phenotype.

(d) Students and their parents



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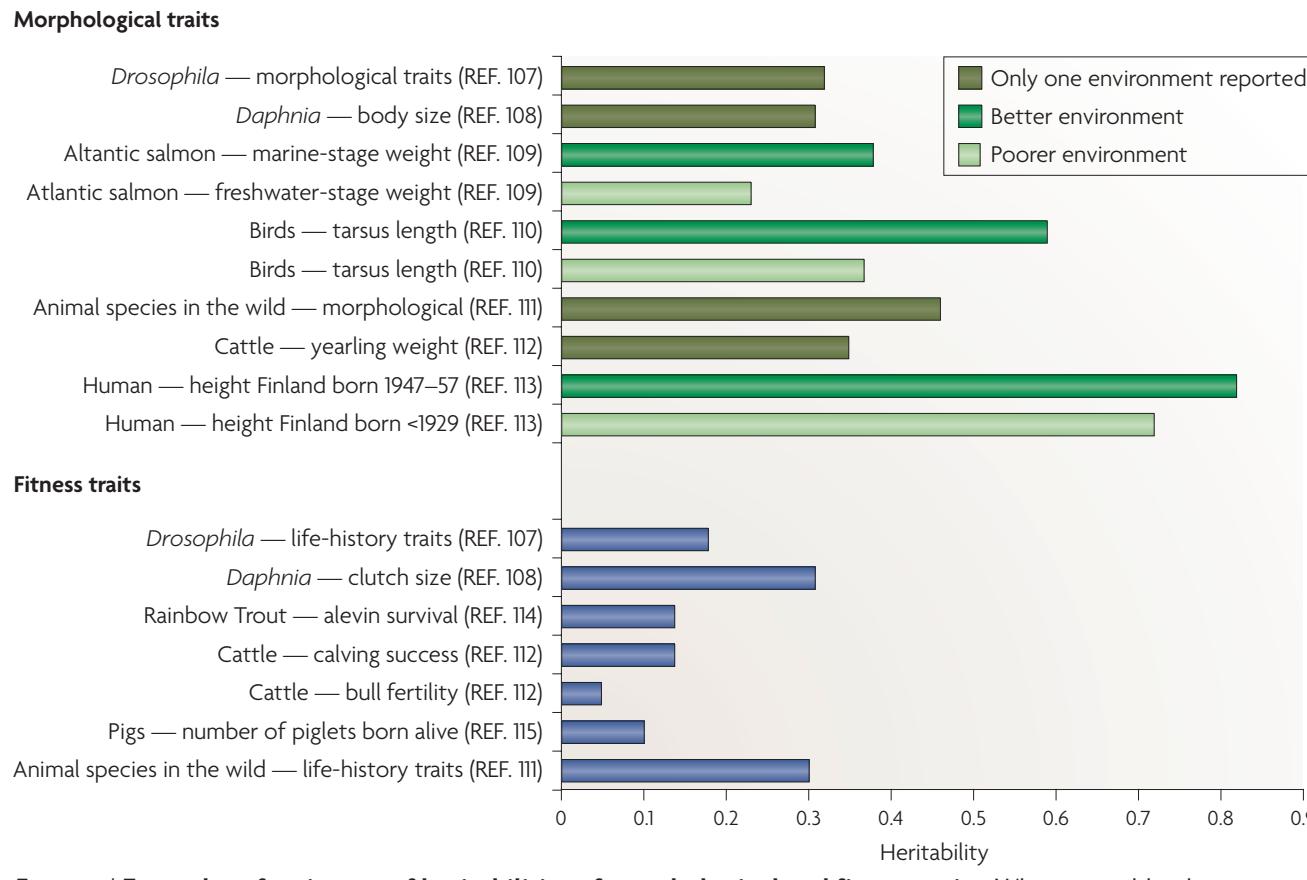


the effect of shared environment

- Need to eliminate the covariance of relatives due to shared environment.
 - This is hard but doable through careful experiments.
 - E.g. cross fostering, or common garden experiments
- Or by use of other pairings of relatives.



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 the worst cases of this

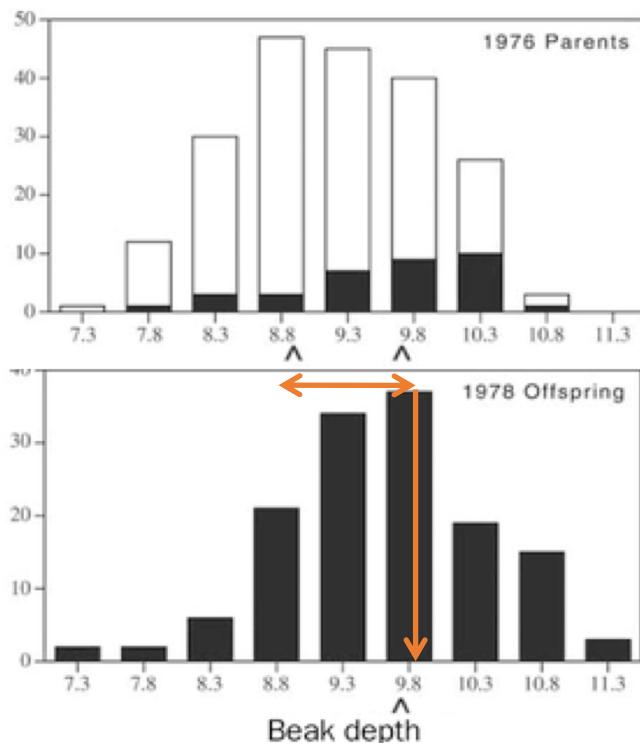
"...Owing to this struggle for life, **any variation, however slight** and from whatever cause proceeding, if it be **in any degree profitable to an individual** of any species, in its infinitely complex relations to other organic beings and to external nature, will tend to the preservation of that individual, **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

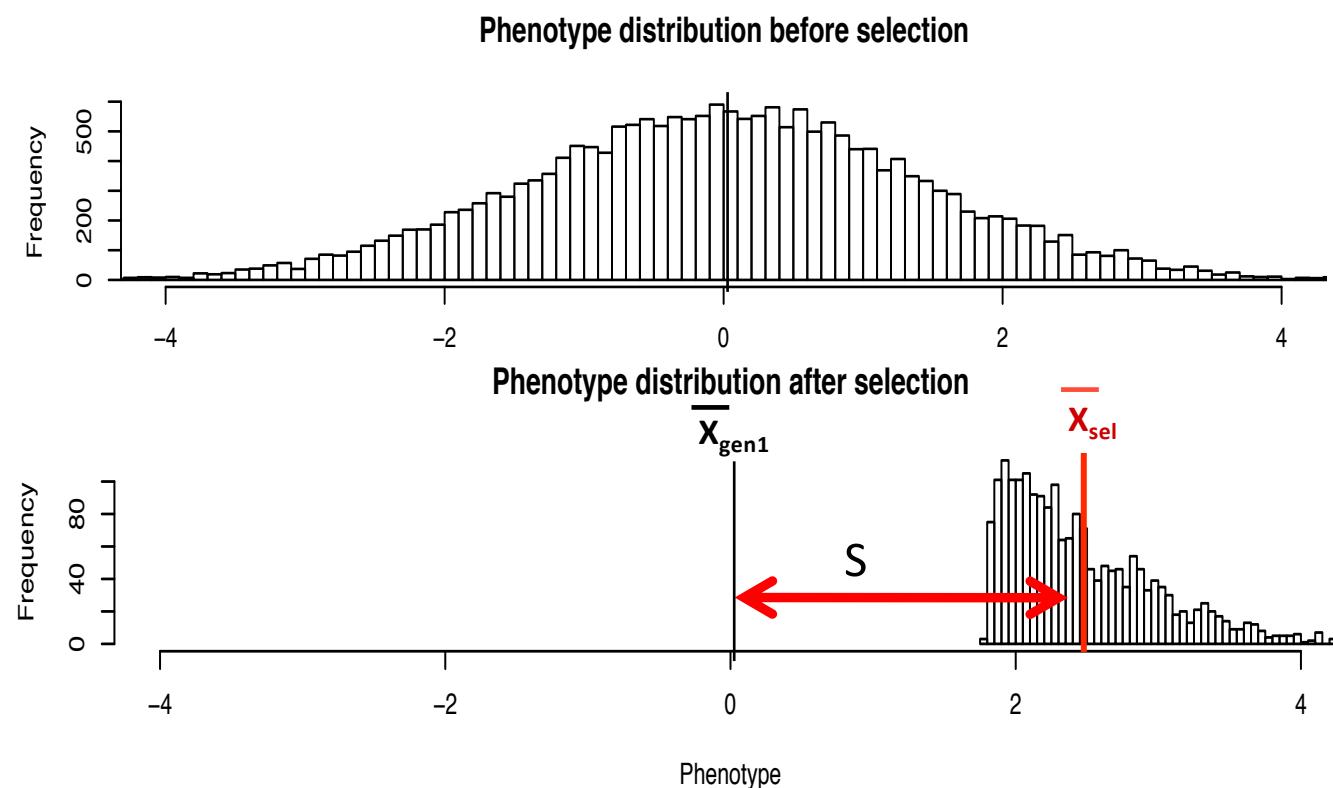
- Evolution by natural selection will only occur if the change in mean phenotype caused by selection can be transmitted to next generation (i.e. it is heritable).



- Natural selection can act on a trait even in absence of genetic variation in that trait.
- However, no 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

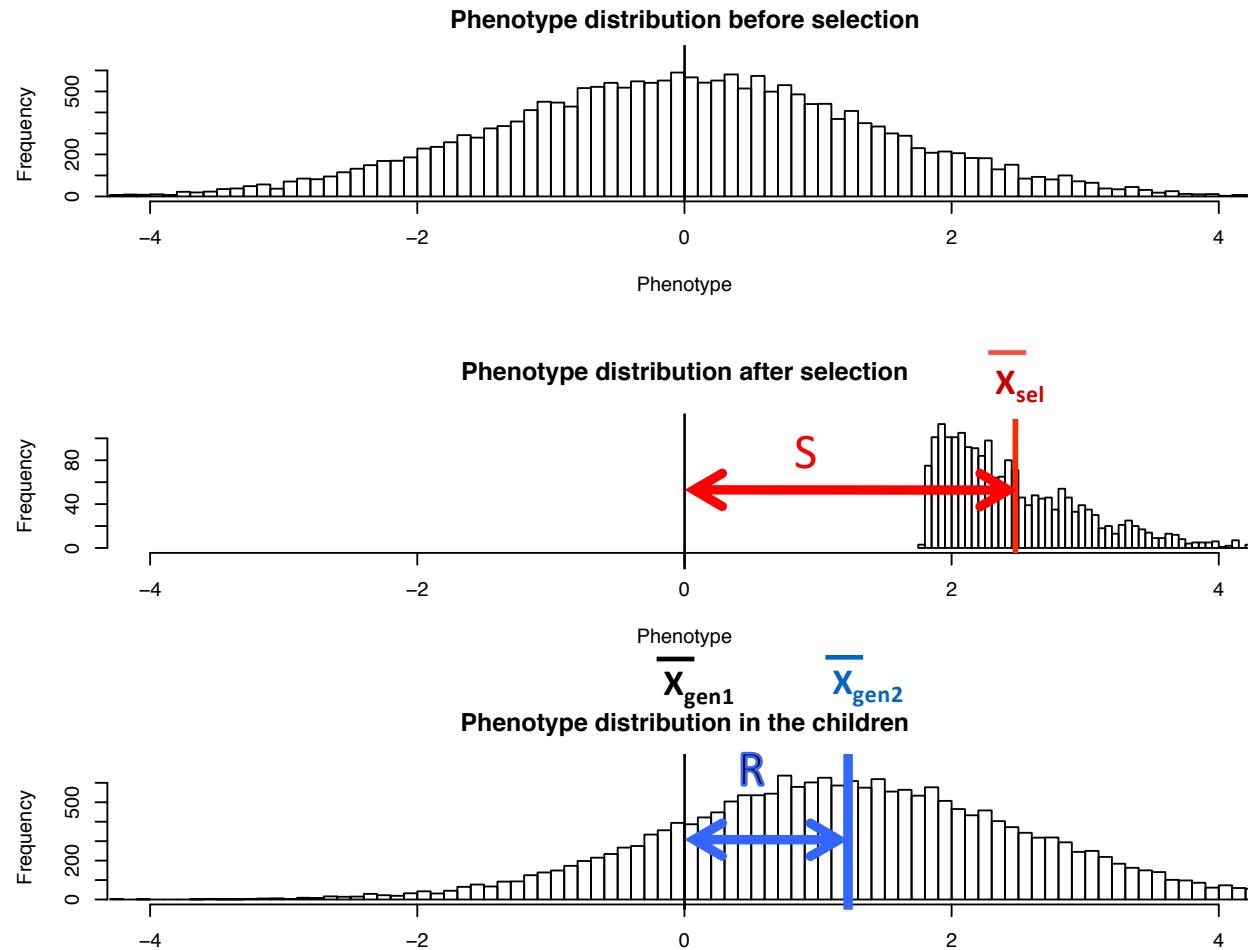
$$= \overline{X}_{\text{sel}} - \overline{X}_{\text{gen1}}$$





R, the selection response, is the change in the trait mean across successive generations

$$= \bar{X}_{\text{gen2}} - \bar{X}_{\text{gen1}}$$



The breeder's equation.

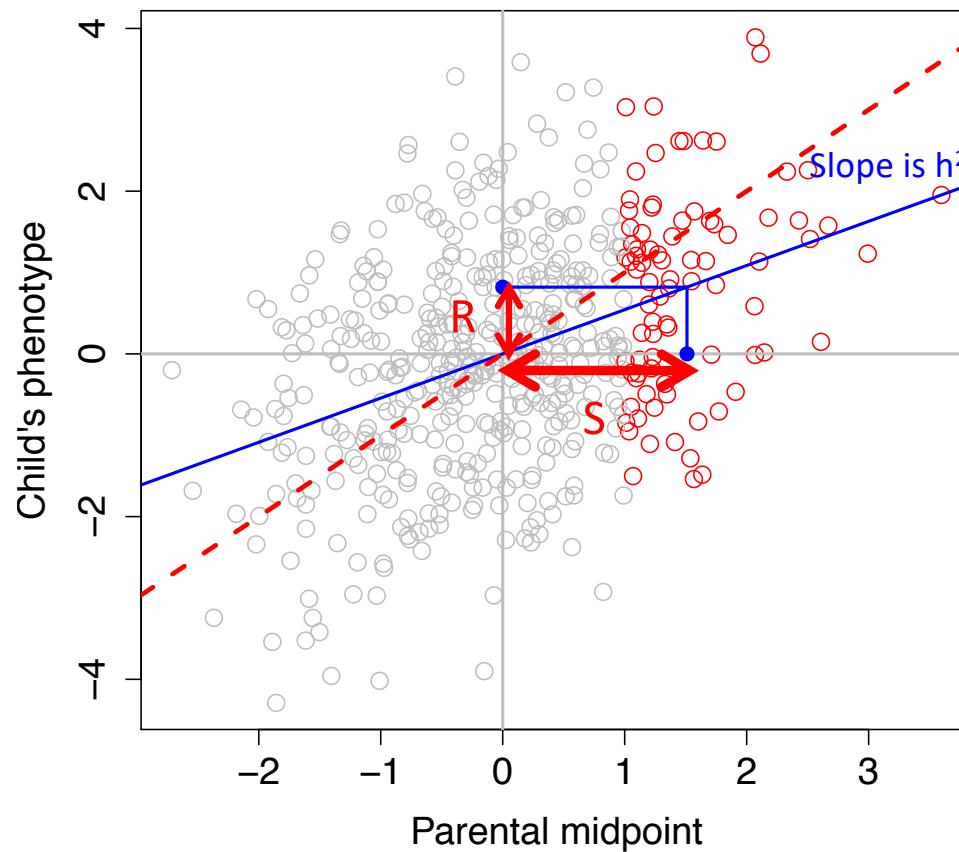
$$R = h^2 S$$

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



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

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