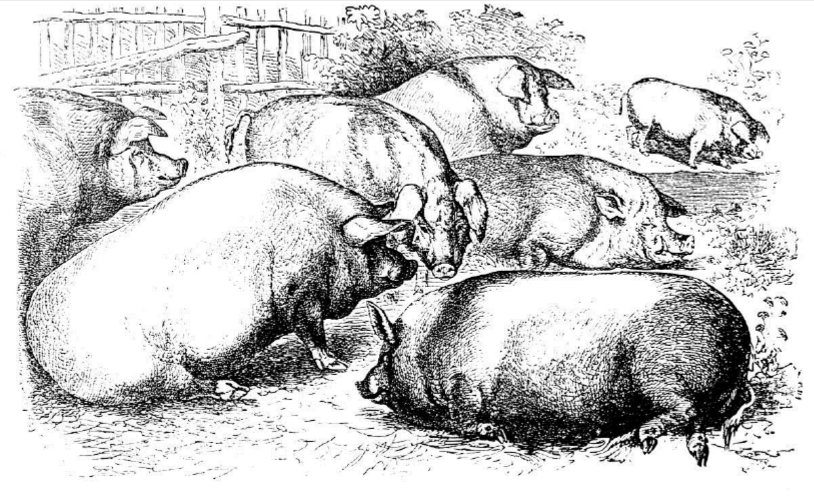
1.3 Inheritance of a Single Trait & Response to Selection



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Thesis

- Most traits are affected by many genes
- We can model the inheritance of such traits with a statistical approach
- Additive genetic variance is the statistical concept that enables us to model both inheritance and response to selection

Outline

1. Phenotypic resemblance between parents and offspring reveals heritable variation.

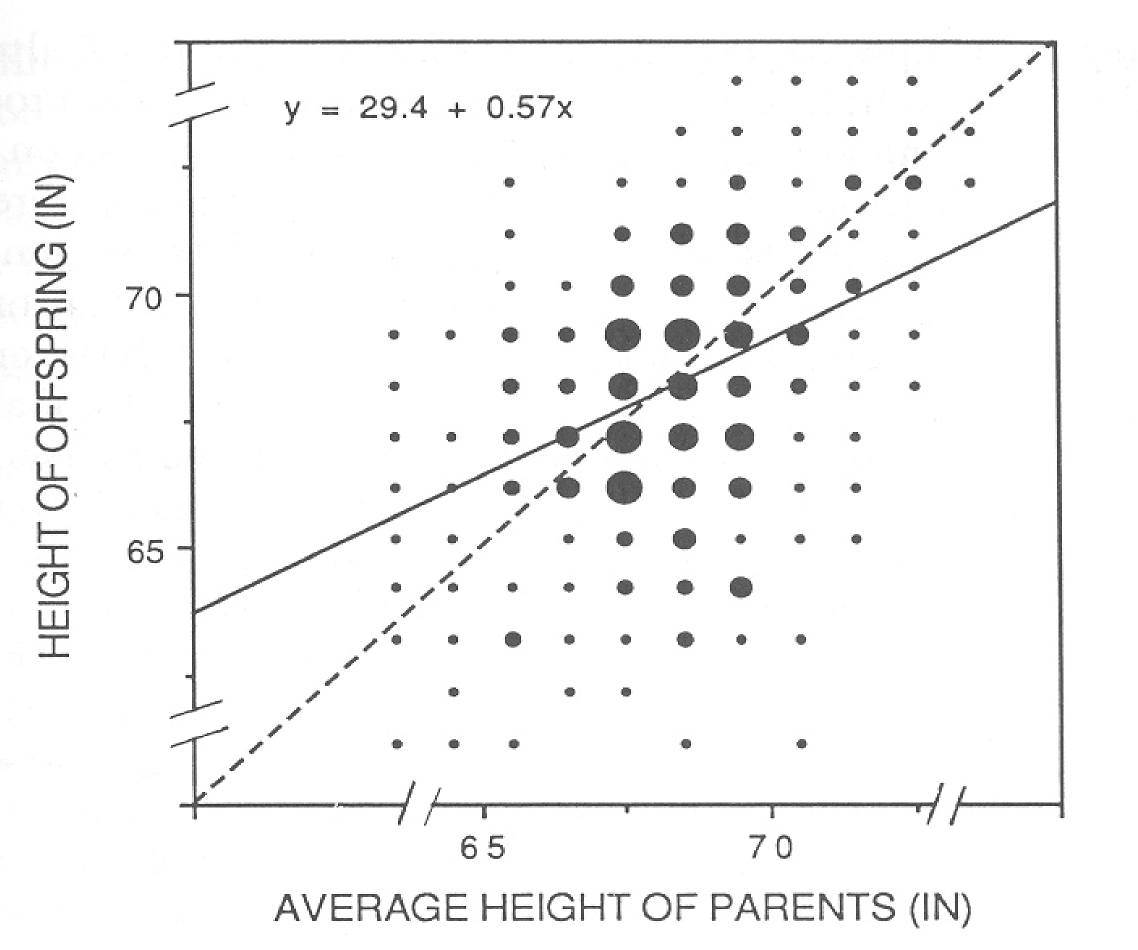
2. To understand resemblance we need a model.

3. Some examples.

4. Why don't we run out of additive genetic variance?

5. Changing the trait mean with selection.

1. Phenotypic resemblance: Galton's plot



2. A Model of Phenotypic Resemblance

a. A model for phenotypic value (from Joe's lecture this morning)

$$P = \mu + \begin{Bmatrix} AA & -2 \\ Aa & 0 \\ aa & 3 \end{Bmatrix} + \begin{Bmatrix} BB & 0.6 \\ Bb & 0.1 \\ bb & -0.2 \end{Bmatrix} + \begin{Bmatrix} CC & -1 \\ Cc & 6 \\ cc & 6 \end{Bmatrix} + \begin{Bmatrix} DD & 0.3 \\ Dd & 0.3 \\ dd & 0.7 \end{Bmatrix} + \begin{Bmatrix} EE & -0.4 \\ Ee & 0.3 \\ ee & -0.3 \end{Bmatrix} + \text{environmental effect}$$

b. An equivalent model, without the locus-by-locus details, for

phenotypic value $z = x + e$

phenotypic mean $\bar{z} = \bar{x} + \bar{e}$

phenotypic variance $P = G + E$

2. A Model of Phenotypic Resemblance

c. A new perspective on Galton's regression

$$h^2 = Cov(z_o, z_p)P^{-1} = Cov(x_o, x_p)P^{-1} = GP^{-1} = G / P$$

Our model identifies additive genetic variance, *G*,
as the key statistical property
responsible for Galton's regression

2. A Model of Phenotypic Resemblance

d. What about resemblance between other kinds of relatives?

We need to include domiance, *d*, and epistasis, *i*, as well as additive effects, *x*

$$z = x + d + i + e$$

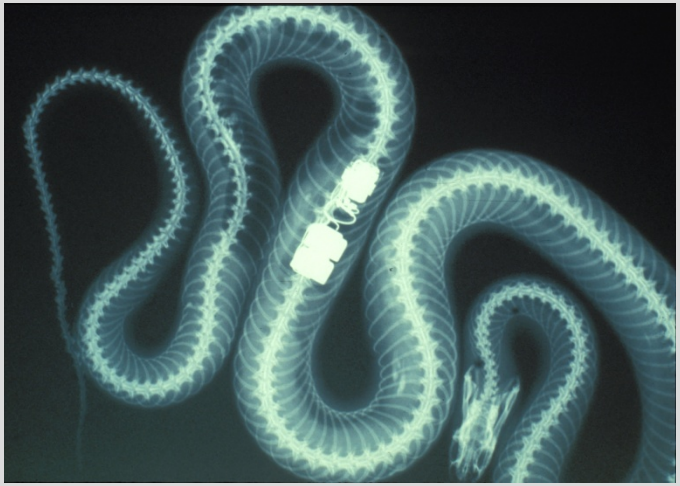
$$i = i_{AA} + i_{AD} + i_{DD} + i_{AAA} + i_{AAD} + i_{ADD} + i_{DDD} + \ldots$$

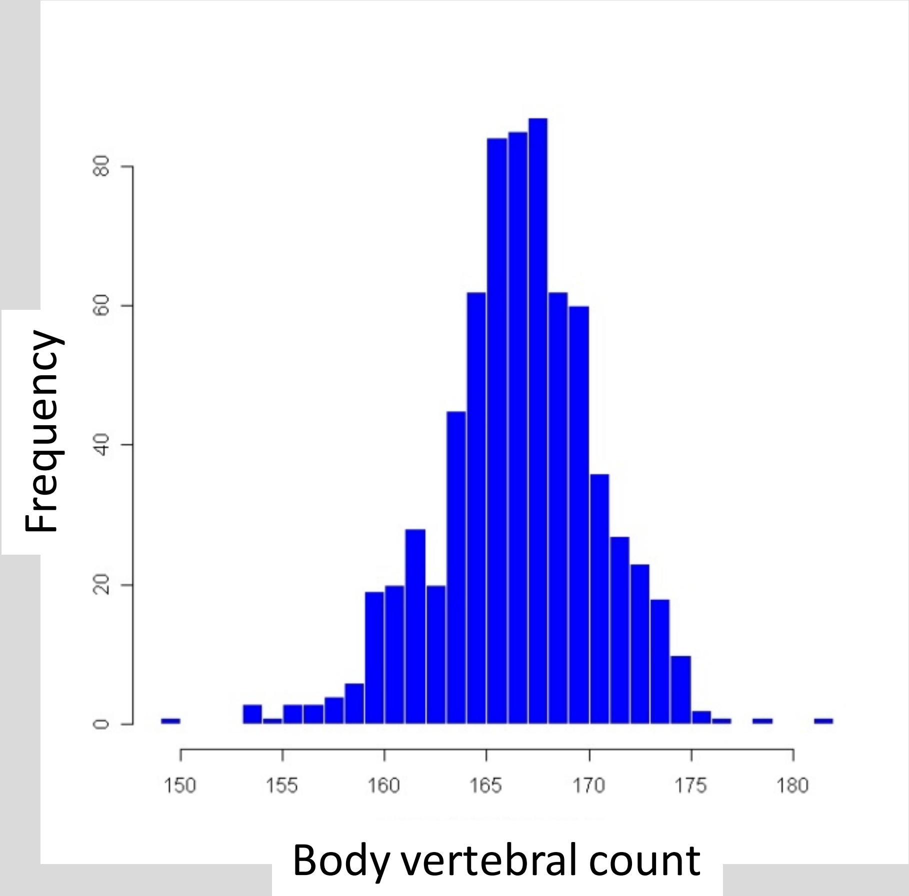
to obtain a general expression for resemblance between relatives *X* and *Y*

$$Cov(X,Y) = rG + uG_D + r^2G_{AA} + ruG_{AD} + u^2G_{DD} + r^3G_{AAA} + r^2uG_{AAD} + ru^2G_{ADD} + u^3G_{DDD} + \ldots \quad (5.6)$$

3. Some examples

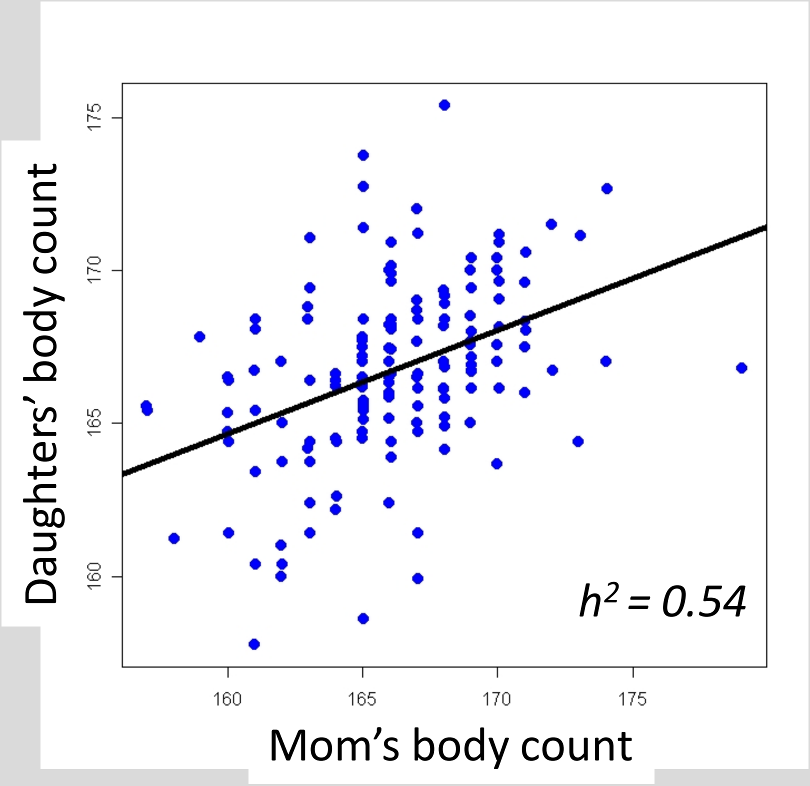
a. Mother-daughter resemblance in vertebral counts in garter snakes

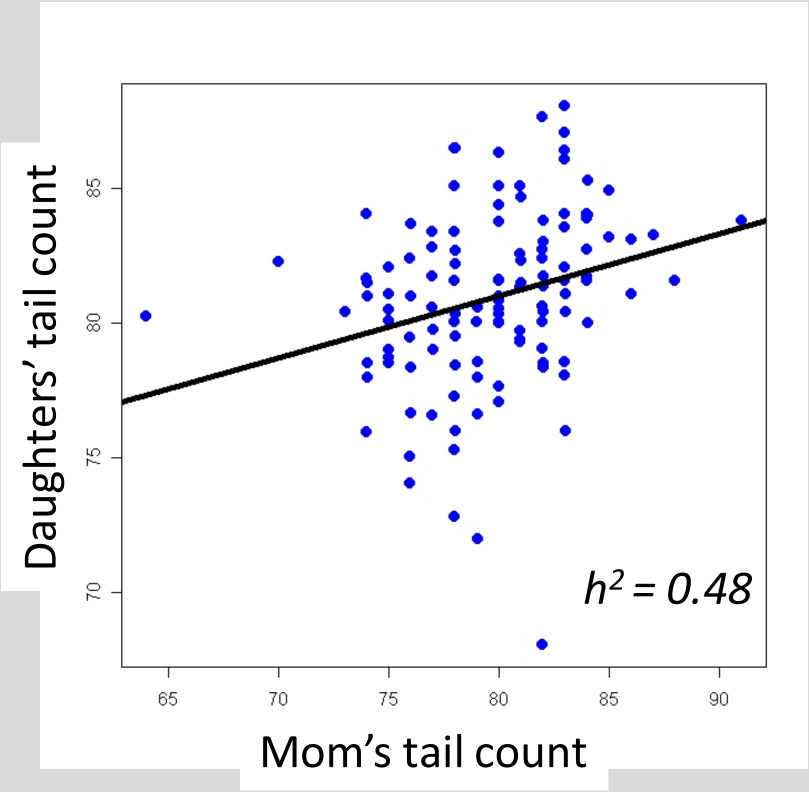




3. Some examples

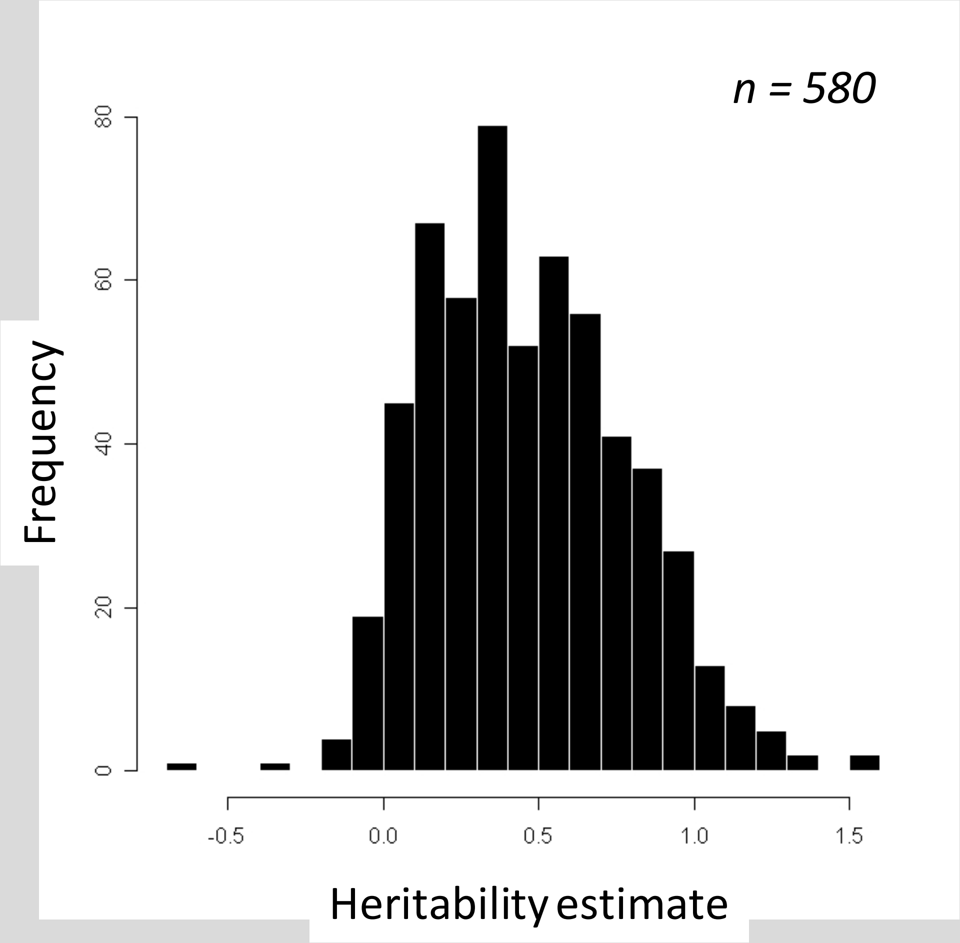
a. Mother-daughter resemblance in vertebral counts in garter snakes





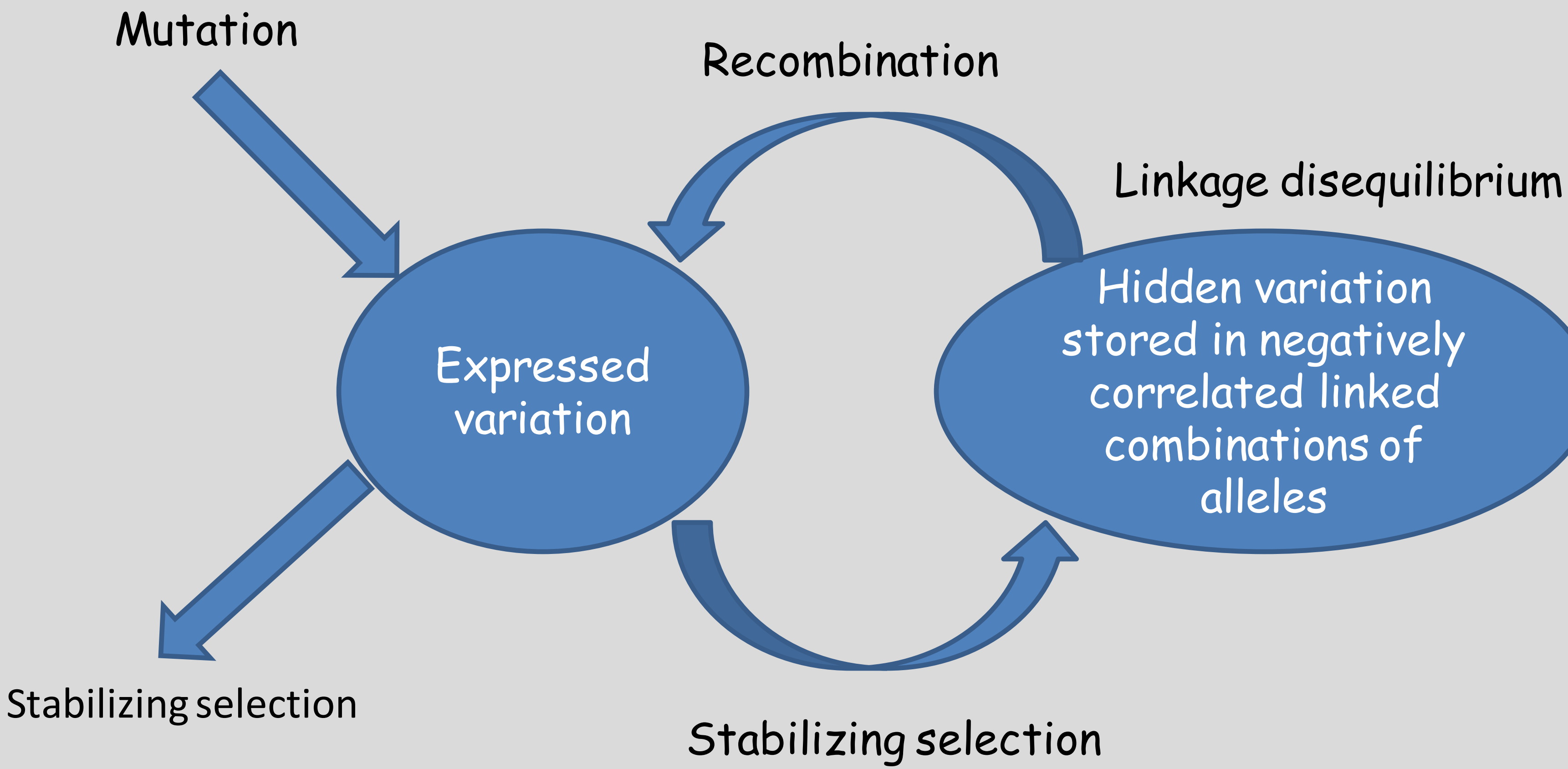
3. Some examples

b. A survey of heritability estimates



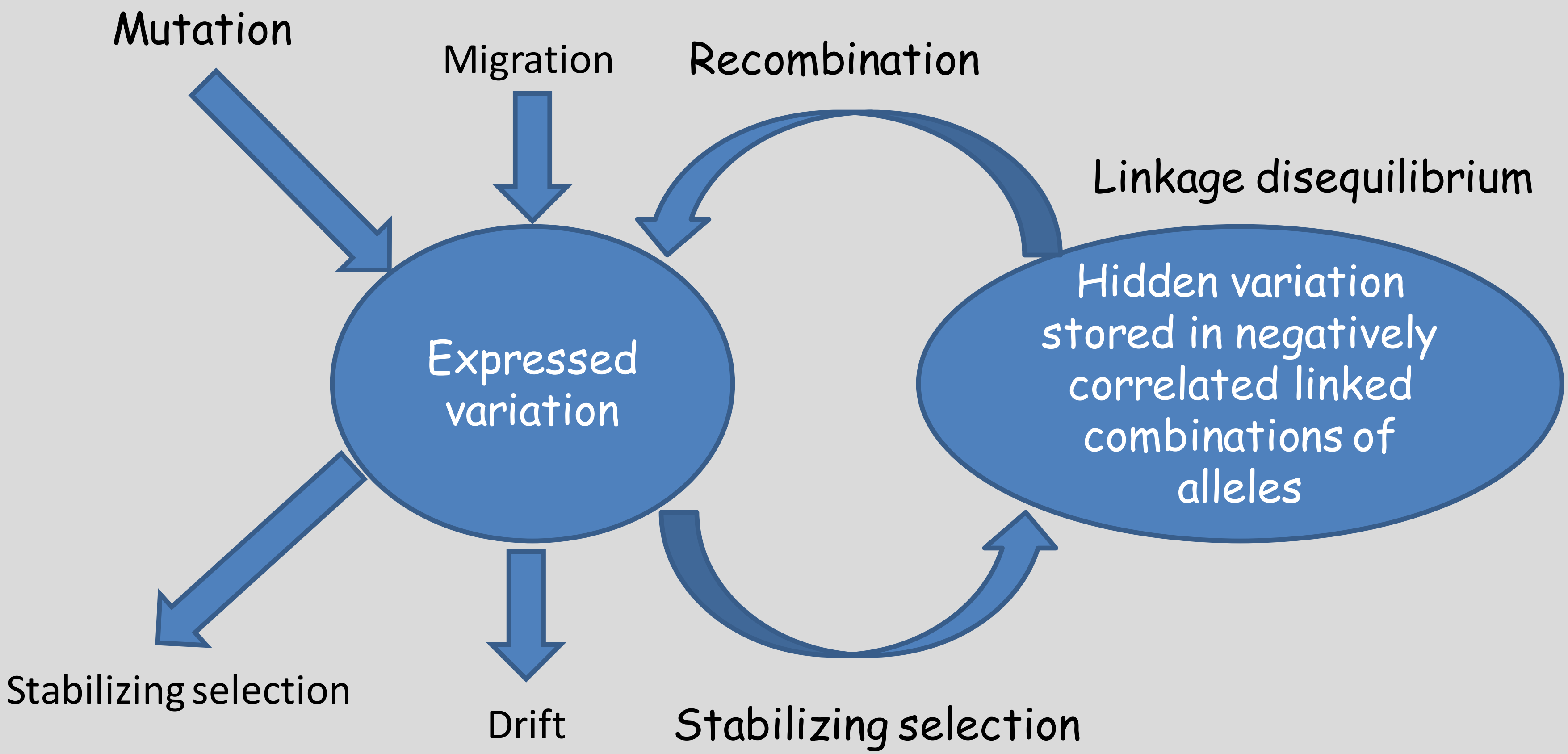
4. Why don't we run out of additive genetic variance?

Mutation-Selection Balance



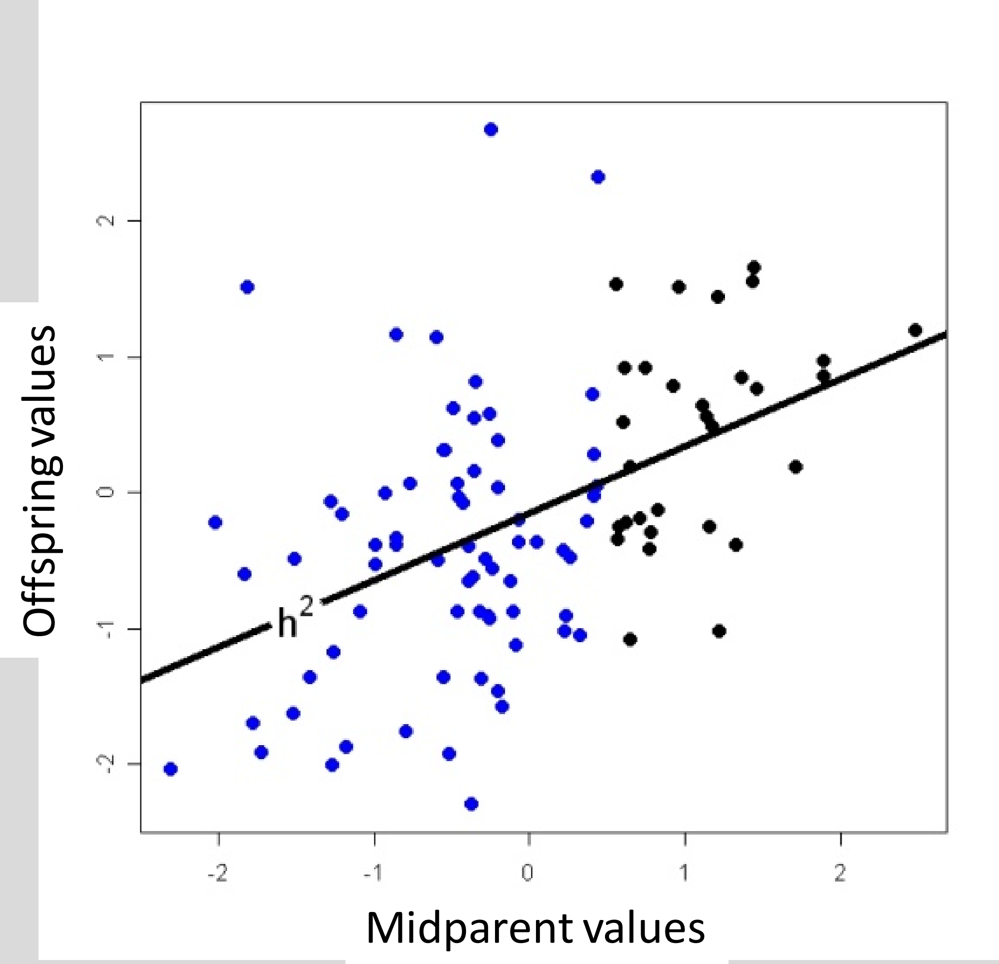
4. Why don't we run out of additive genetic variance?

Mutation-Migration-Selection-Drift Balance



5. Changing the trait mean with selection

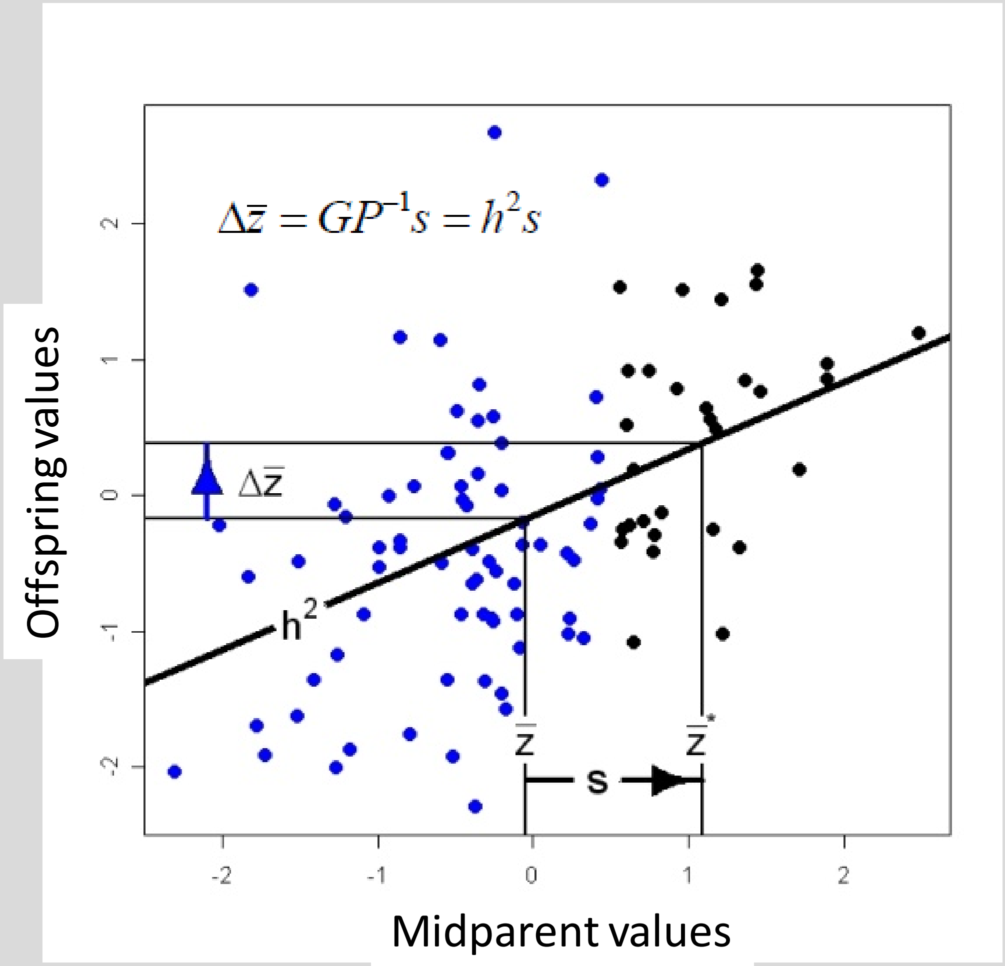
a. Response to selection as a regression problem



Heritability = h^2

5. Changing the trait mean with selection

a. Response to selection as a regression problem

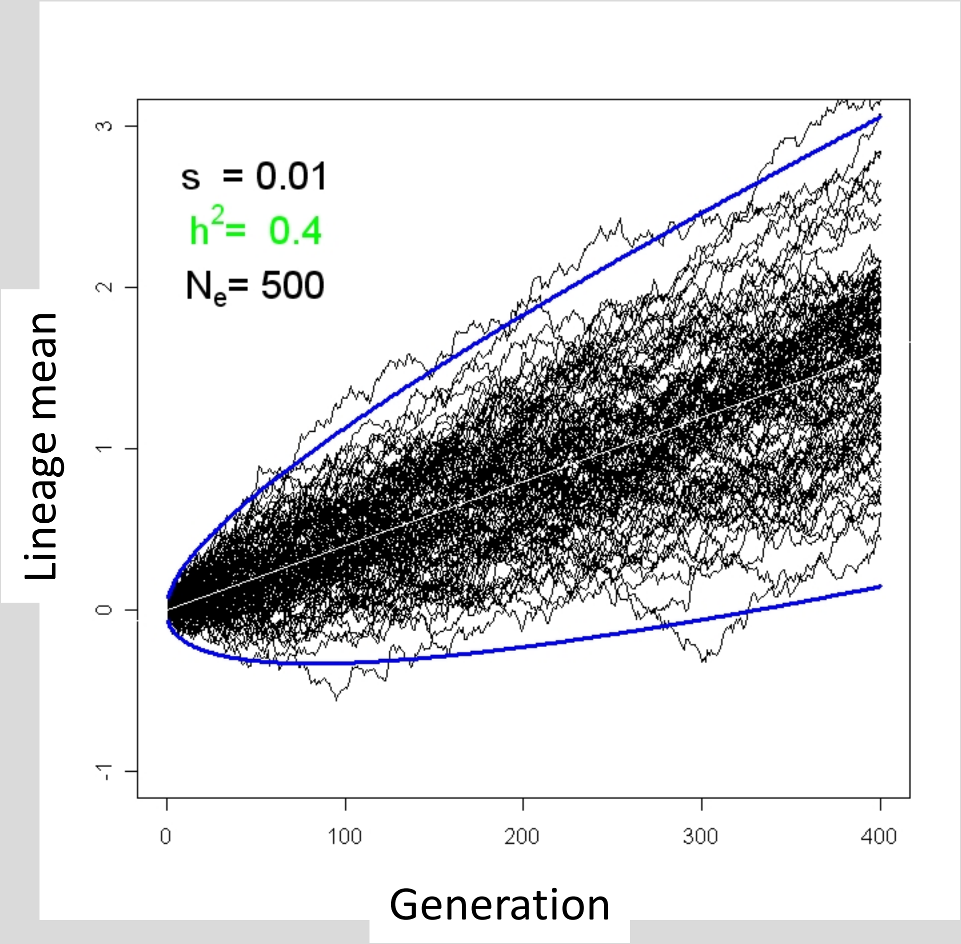


Selection differential

$$s = \bar{z}^* - \bar{z}$$

5. Changing the trait mean with selection

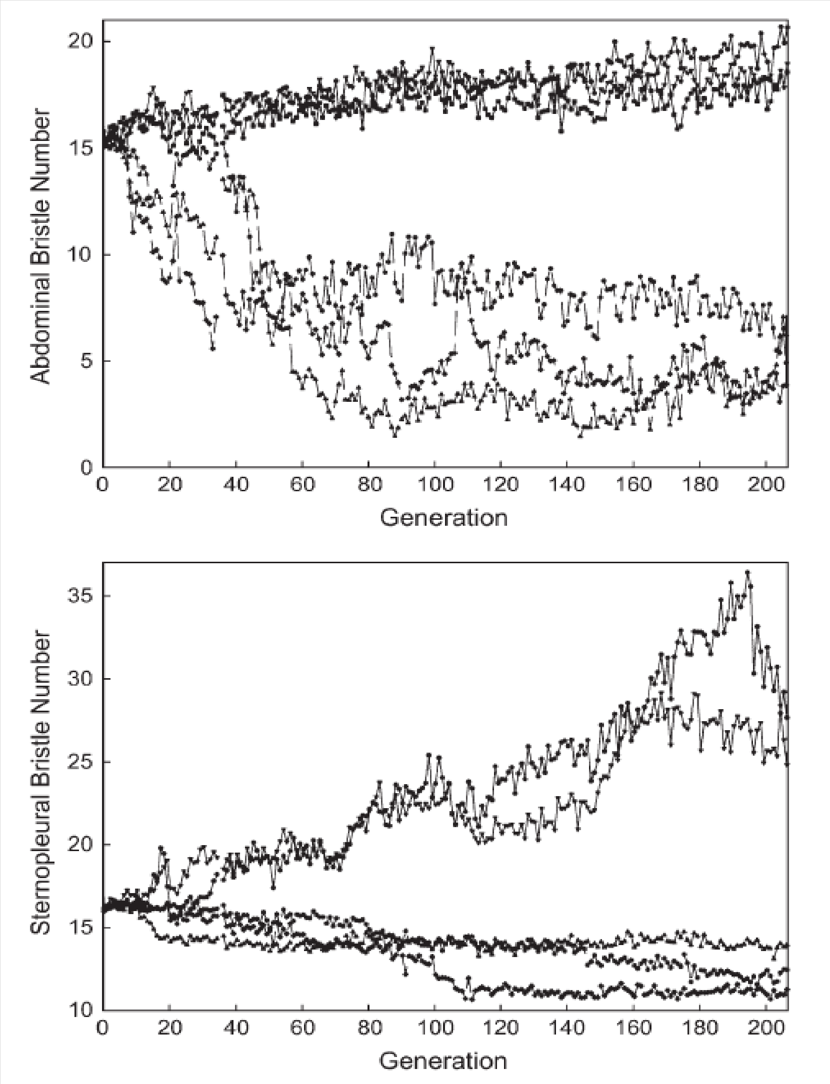
b. Response to selection in a finite population



[Animation]

5. Changing the trait mean with selection

c. Response to long term selection for bristle numbers in *Drosophila*



What have we learned?

1. Additive genetic variance, *G*, is the key to understanding resemblance between parents and offspring.

2. Consequently, *G* is also the key to modeling response to selection.

3. *G* is nibbled away by selection but restored by mutation (and migration).

References

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