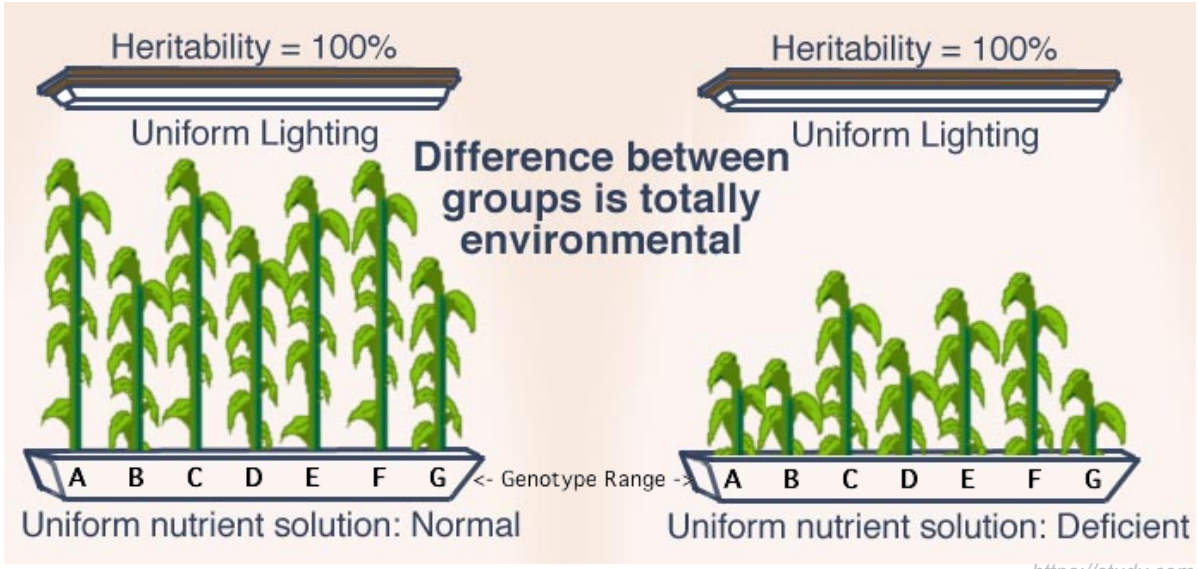
The inheritance of complex traits

The inheritance of complex traits

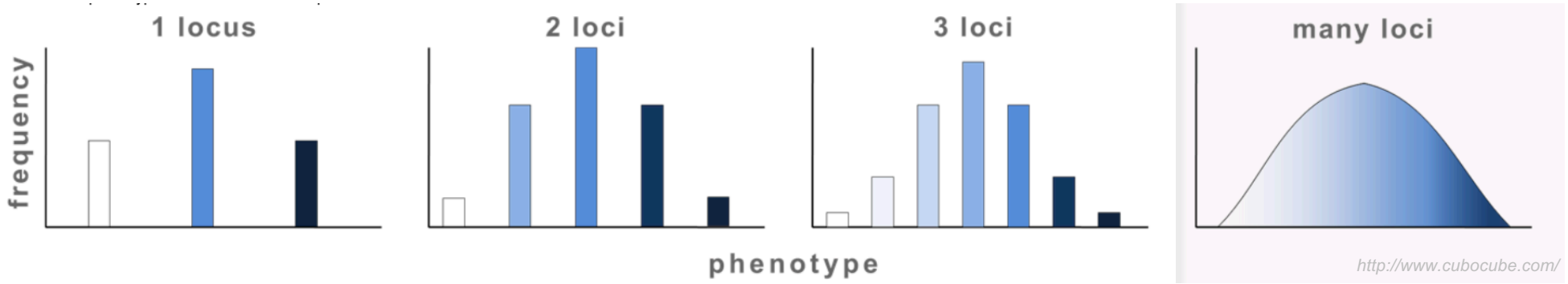
- Quantitative variation: Mean, variance, standard deviation
- Genetic model
- Genetic and environmental variances
- Heritability: Broad and narrow sense



https://study.com/

Quantitative variation

Traits that show a continuous range of variation and don’t behave is a simple Mendelian fashion are known as quantitative or complex traits



Quantitative genetics!

Basic statistical concepts

- Mean

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

$$\bar{X} = \frac{X_1 + X_1 + X_{1\ldots}X_n}{n}$$

Where
$\bar{X}$ = mean
X_1 = first value
X_2 = second value
X_3 = third value
X_n = last value
n = number of samples

Basic statistical concepts

- Mean

$$\overline{X} = \sum_{i=1}^{k} f_i X_i$$

Where
$\bar{X}$ = mean
k = classes
f = frequency

$\bar{X} = (X_1 * f_1) + (X_2 * f_2) + (X_3 * f_3)$

Height (cm)	Count	Frequency × Height
156	1	1.56
157	2	3.14
158	1	1.58
159	2	3.18
160	1	1.60
161	1	1.61
162	2	3.24
164	7	11.48
165	7	11.55
166	1	1.66
167	6	10.02
168	9	15.12
169	7	11.83
170	9	15.30
171	5	8.55
172	5	8.60
173	6	10.38
174	5	8.70
175	6	10.50
176	3	5.28
177	4	7.08
178	2	3.56
179	2	3.58
180	2	3.60
181	2	3.62
184	2	3.68
Sum	100	170.00

Griffiths et al 2012

$$\bar{X} = (0.01 \times 156) + (0.02 \times 157) + \cdots + (0.02 \times 184) = 170$$

Basic statistical concepts

- Mean

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

$$\overline{X} = \sum_{i=1}^{k} f_i X_i$$

The expected value is the average of all the values we would observe if we measured X many times:

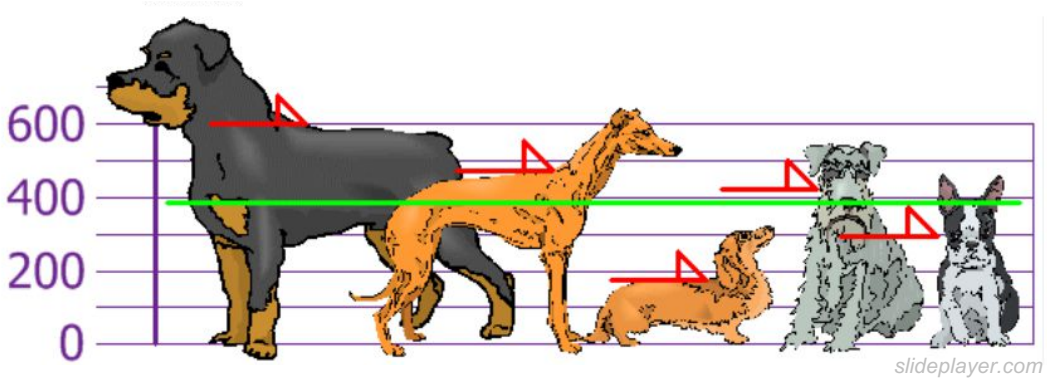
$$E(X) = \bar{X}$$

Basic statistical concepts

- **Variance:**

Measure of dispersion about the mean.

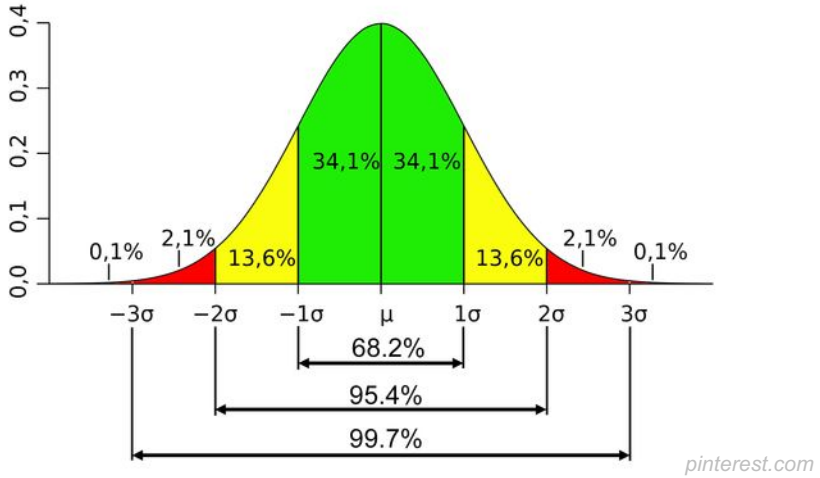
$$s^2 = \frac{1}{n-1}\sum_i (X_i - \bar{X})^2$$



- **Standard deviation**

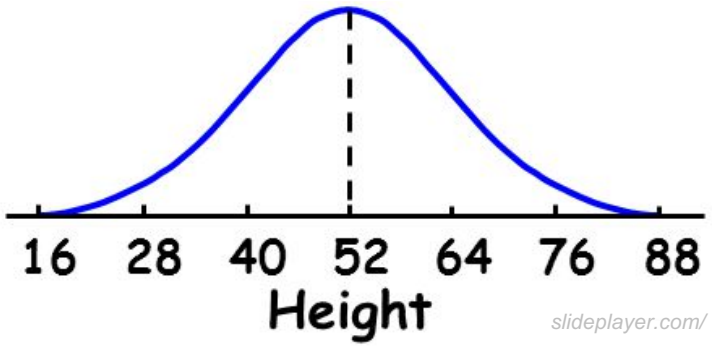
$$s = \sqrt{\frac{1}{n}\sum_i (X_i - \bar{X})}$$

$$= \sqrt{s^2}$$



Simple genetic model

$$X = \bar{X} + g + e$$



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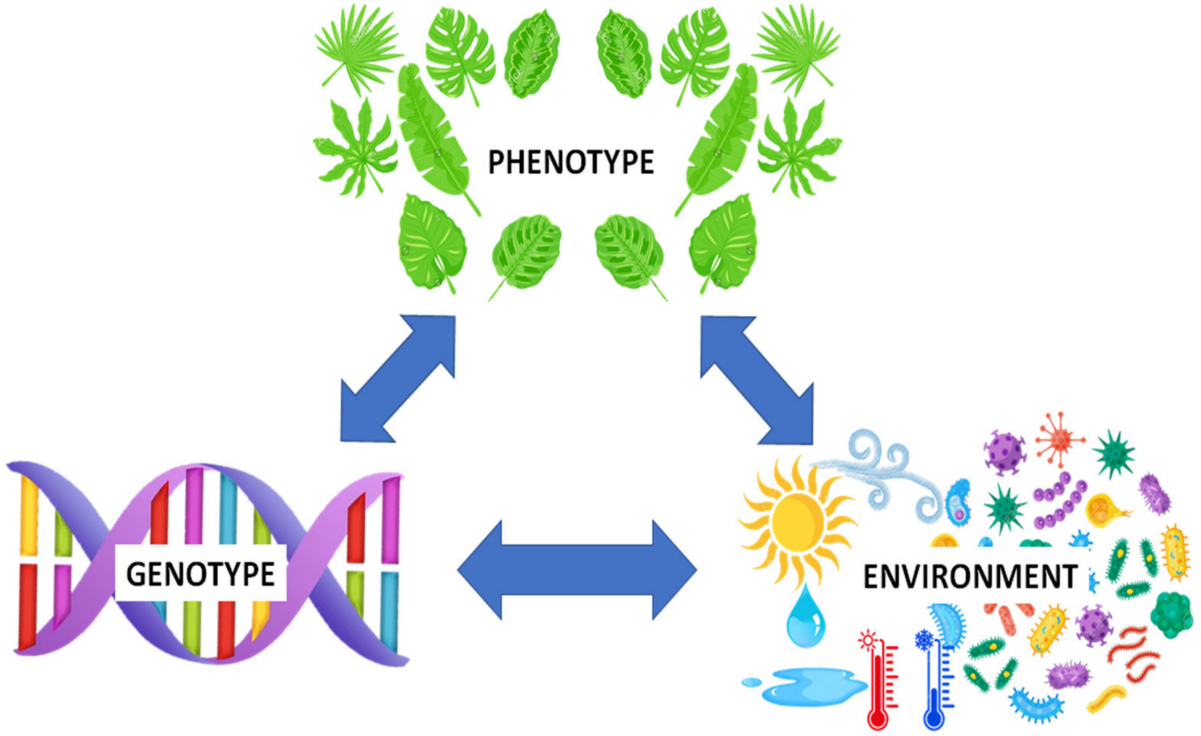


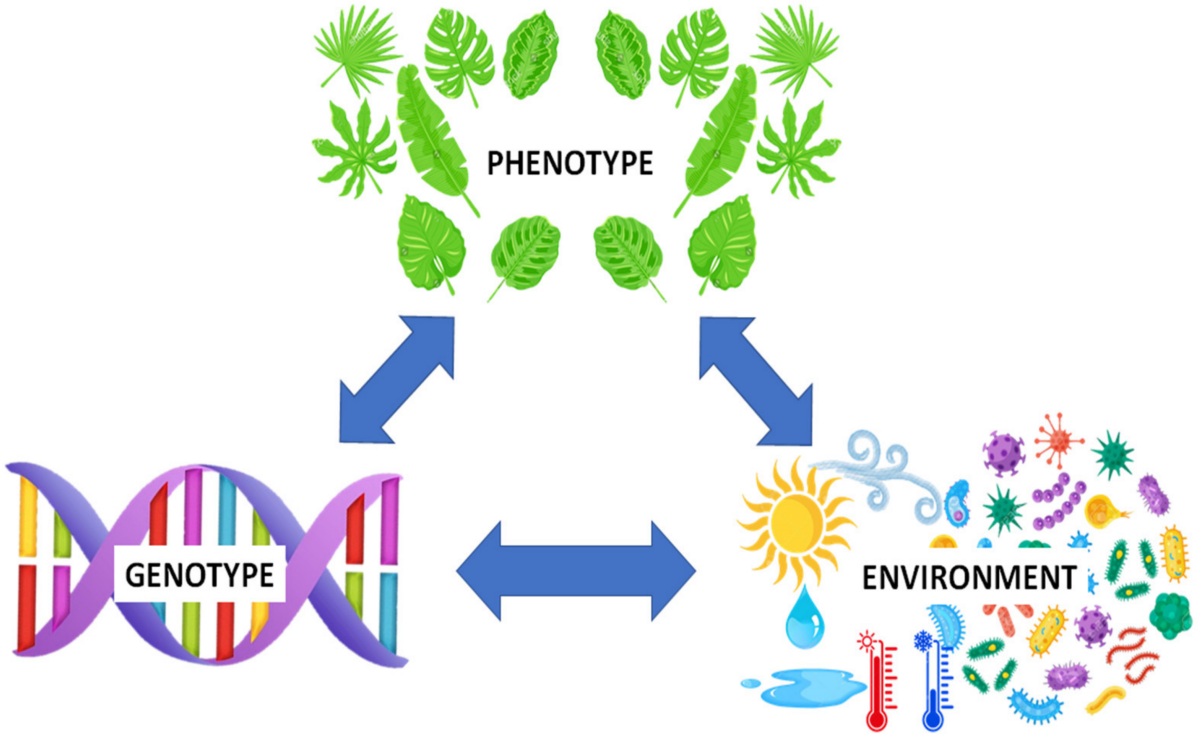
Djande et al 2020

Simple genetic model

$$X = \bar{X} + g + e$$

$$x = g + e$$

x is the individual's phenotypic deviation.



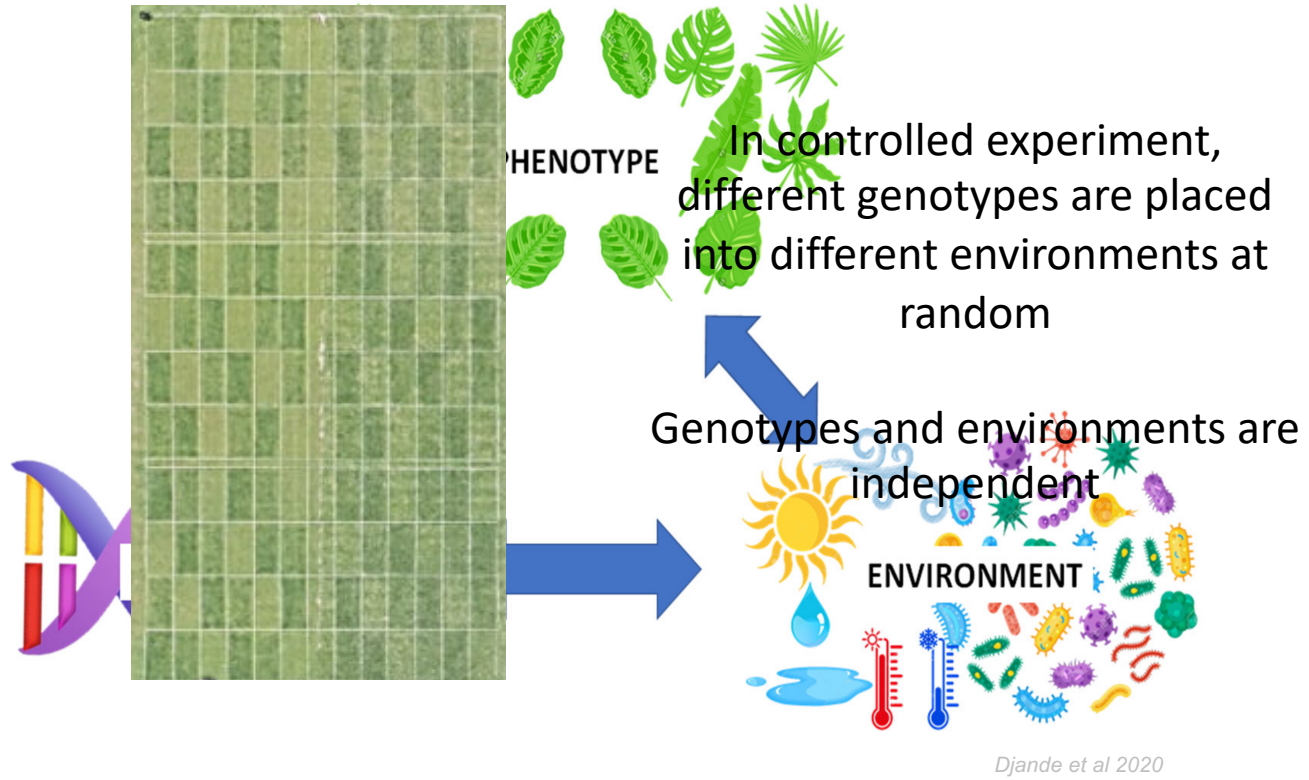
Djande et al 2020

Genetic and environmental variances

$$x = g + e$$

$$V_x = Vg + Ve + 2covge$$

$$V_x = Vg + Ve$$



Heritability

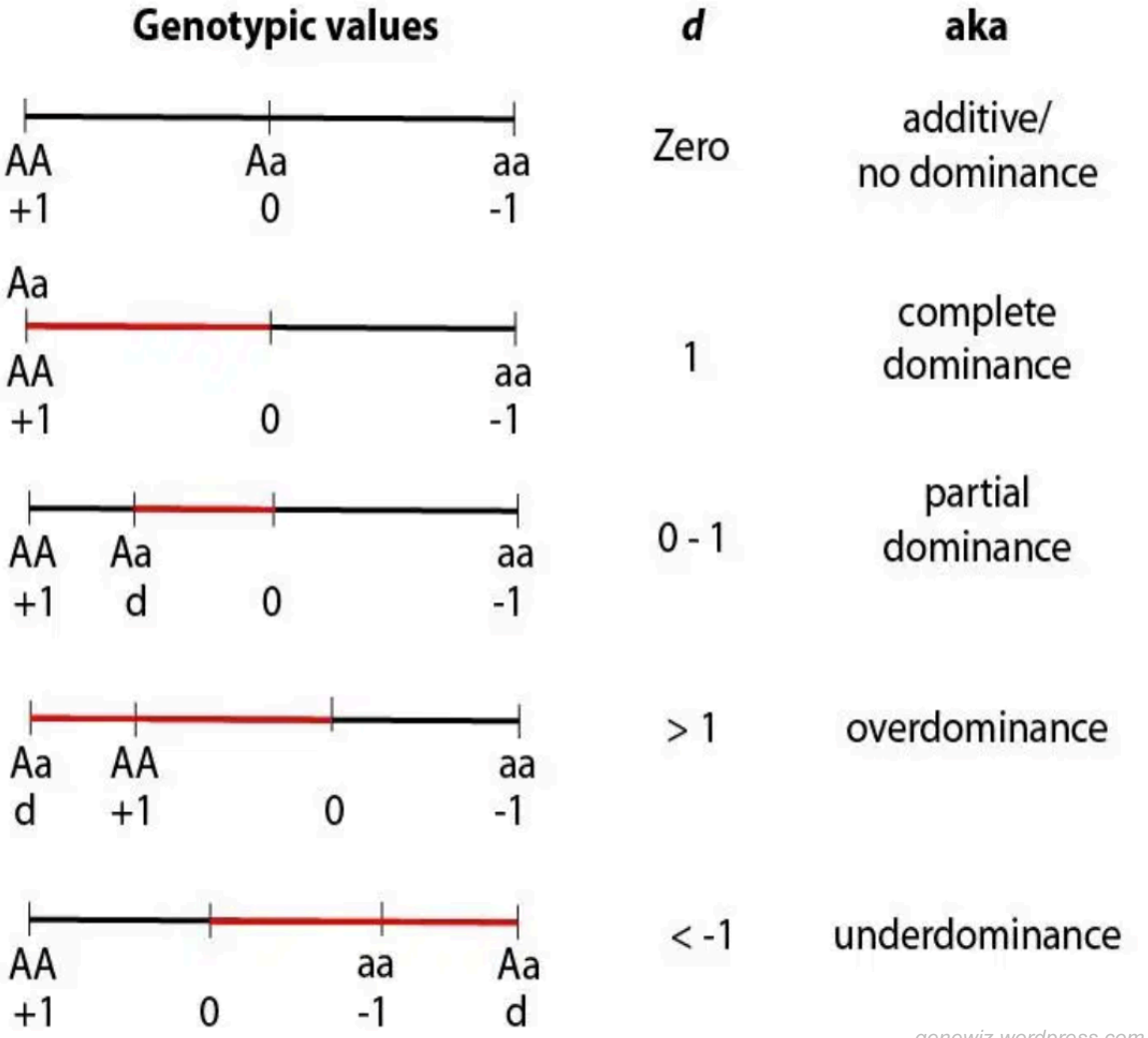
- It is the degree of variation in a phenotypic trait in a population that is due to genetic variation between individuals in that population.

$$V_x = Vg + Ve$$

Broad-sense heritability (H^2)

$$H^2 = \frac{Vg}{Vx}$$

$V_g = V_A + V_D + V_I$



genewiz.wordpress.com

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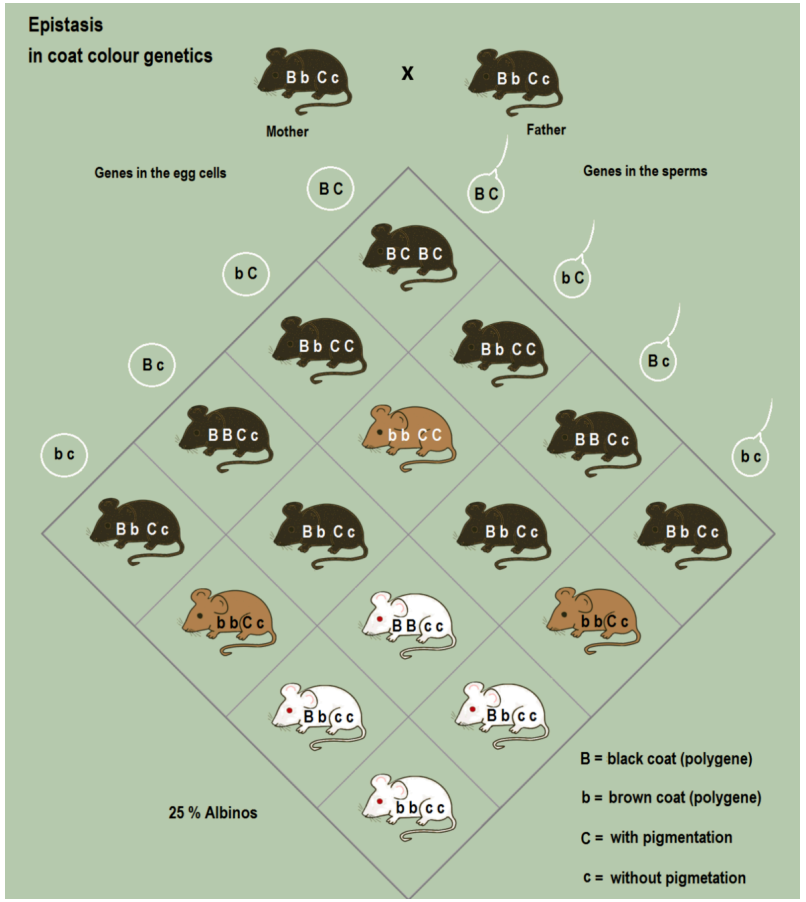


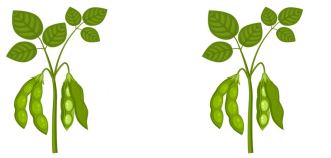
en.wikipedia.org

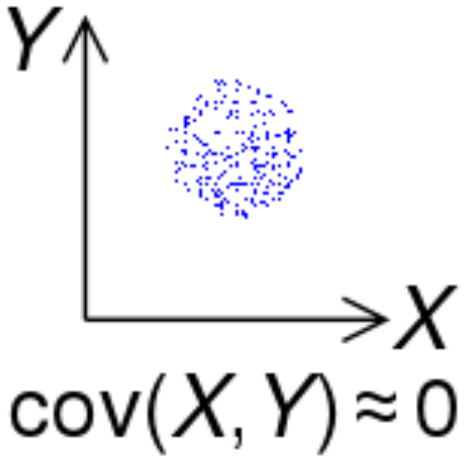
Heritability

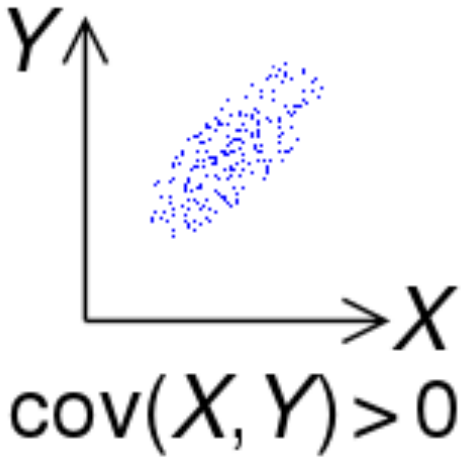
Broad-sense heritability (H^2)

$$H^2 = \frac{Vg}{Vx} = \frac{Cov\ x', x''}{Vx}$$

$$Cov_{xy} = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{(n-1)}$$







en.wikipedia.org

Heritability

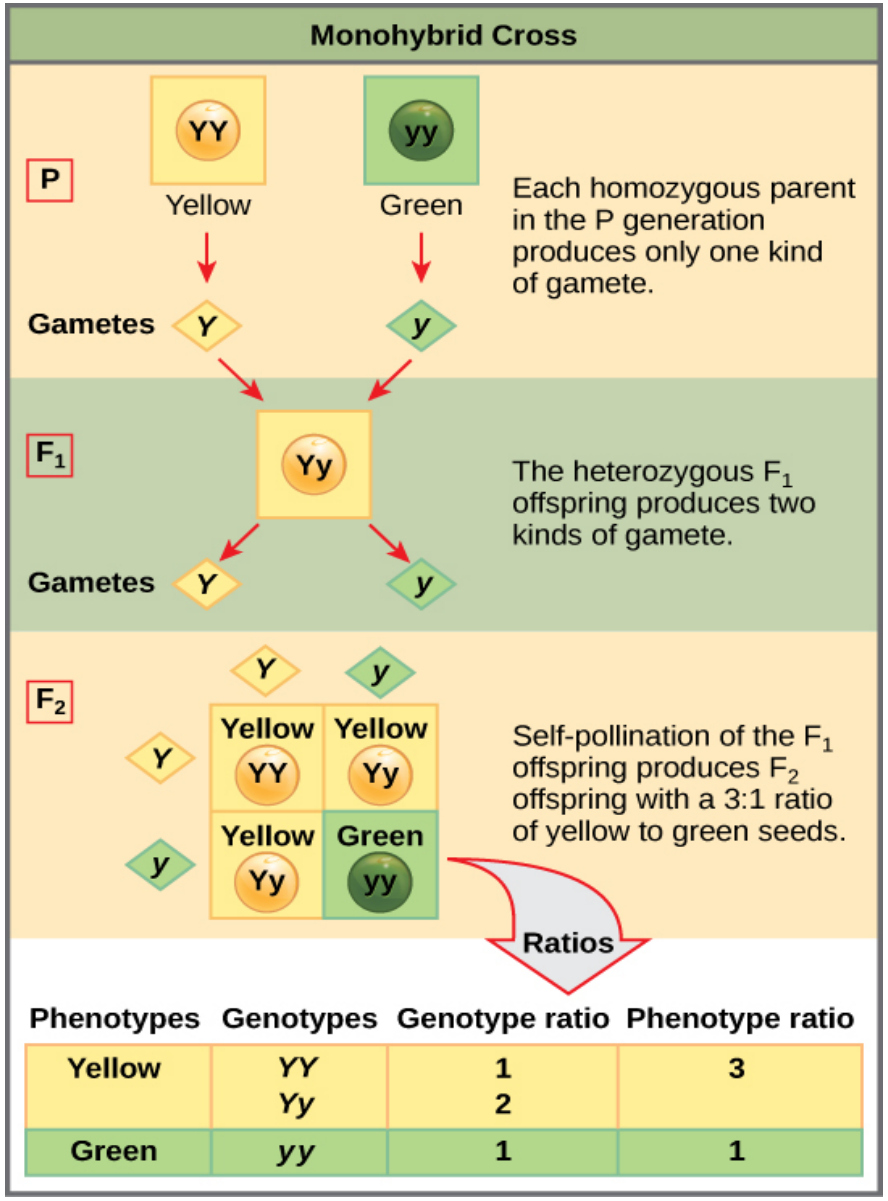
Broad-sense heritability (H^2)

$$H^2 = \frac{Vg}{Vx}$$

$$V_g = V_a + V_d + V_i$$

H^2 is not transmissible to the next generation in a predictive way!

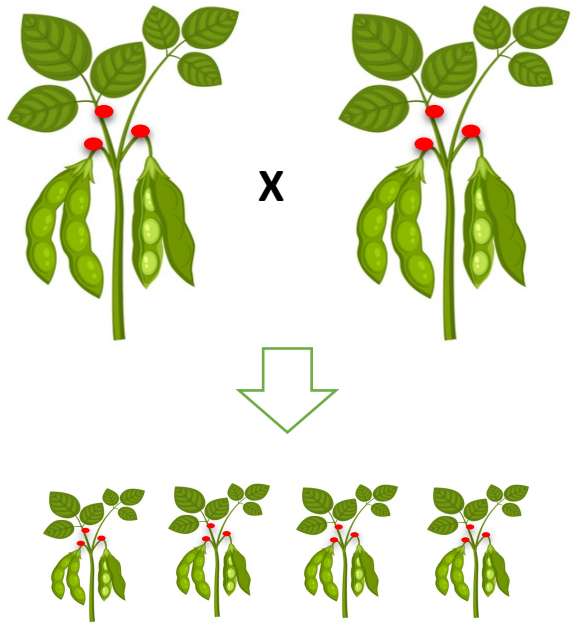
Parents transmit their genes **but not** their genotypes!

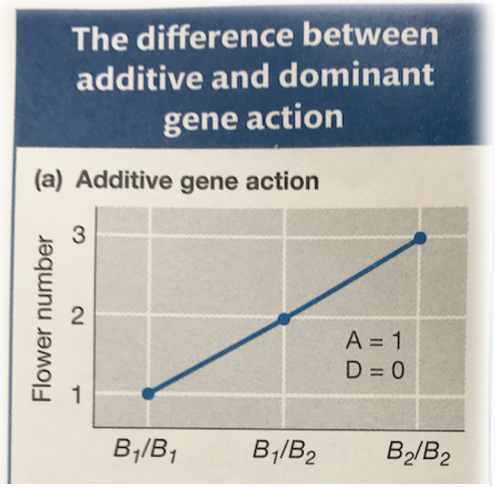


Heritability

Narrow-sense heritability (h^2)

$$h^2 = \frac{Va}{Vx} = \frac{Va}{Va+Vd+Vi+Ve}$$





Griffiths et al 2012

h^2 is transmissible to the next generation in a predictive way!

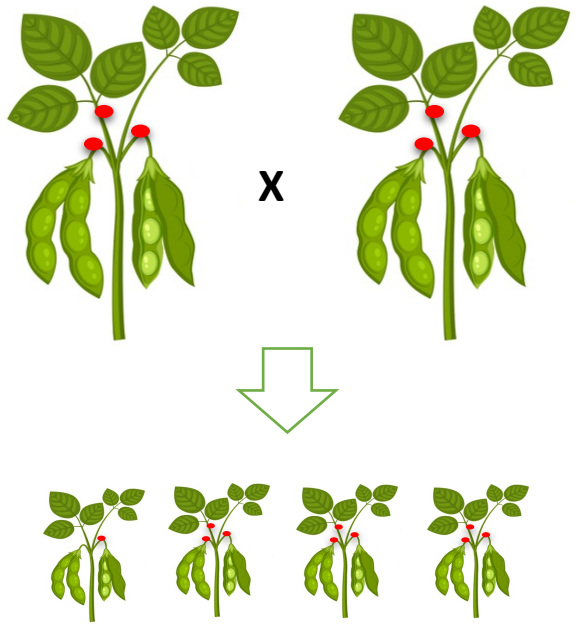
Genotype	Frequency	Trait value (no. of flowers)	Contribution to the mean (frequency × value)
B_1/B_1	0.25	1	0.25
B_1/B_2	0.50	2	1.0
B_2/B_2	0.25	3	0.75
			Mean = 2.0

Heritability

Narrow-sense heritability (h^2)

$$h^2 = \frac{Va}{Vx} = \frac{Va}{Va+Vd+Vi+Ve}$$

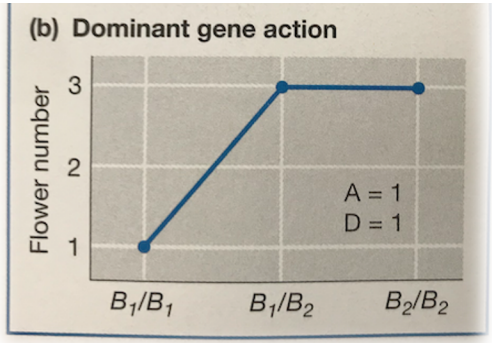
parents = 3



Offspring < 3 (2.78)

The phenotype is not fully heritable!

The difference between additive and dominant gene action



Griffiths et al 2012

Genotype	Frequency	Phenotype	Contribution to the mean (frequency × value)
B_1/B_1	0.25	1	0.25
B_1/B_2	0.50	3	1.5
B_2/B_2	0.25	3	0.75
			Mean = 2.5

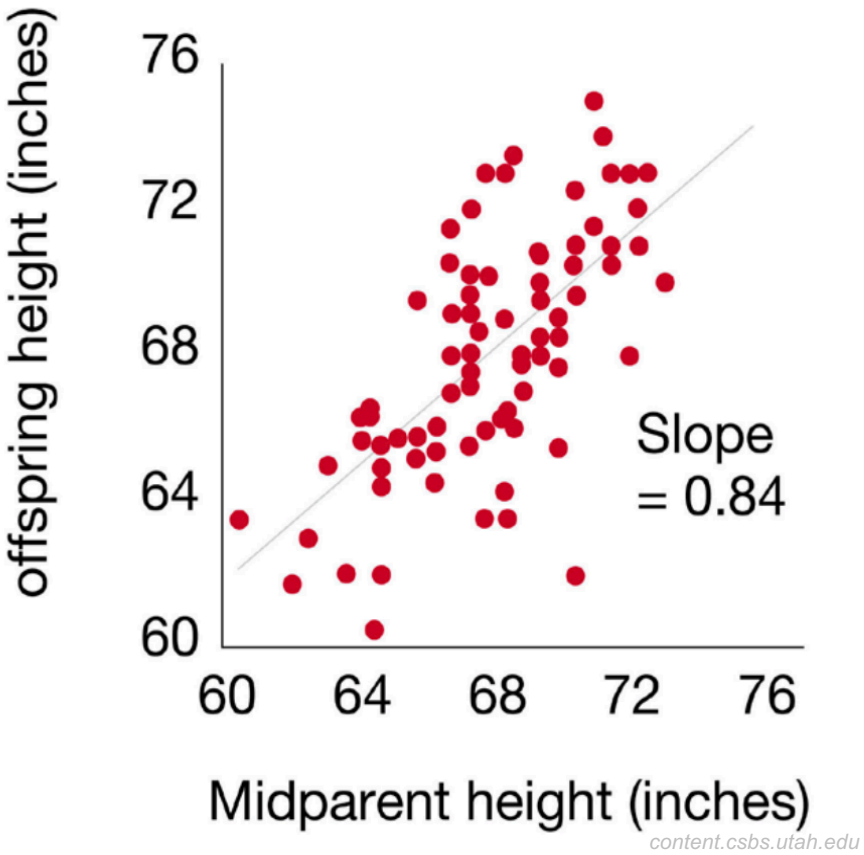
Heritability

Narrow-sense heritability (h^2)

$$h^2 = \frac{Va}{Vx}$$

h^2 is transmissible to the next generation in a predictive way!

$$\beta_{O\sim Mp} = \frac{Cov(u_{ih}, u_i)}{Var(y_i)} = \frac{\sigma_a^2}{\sigma_p^2} = h^2$$



Heritability

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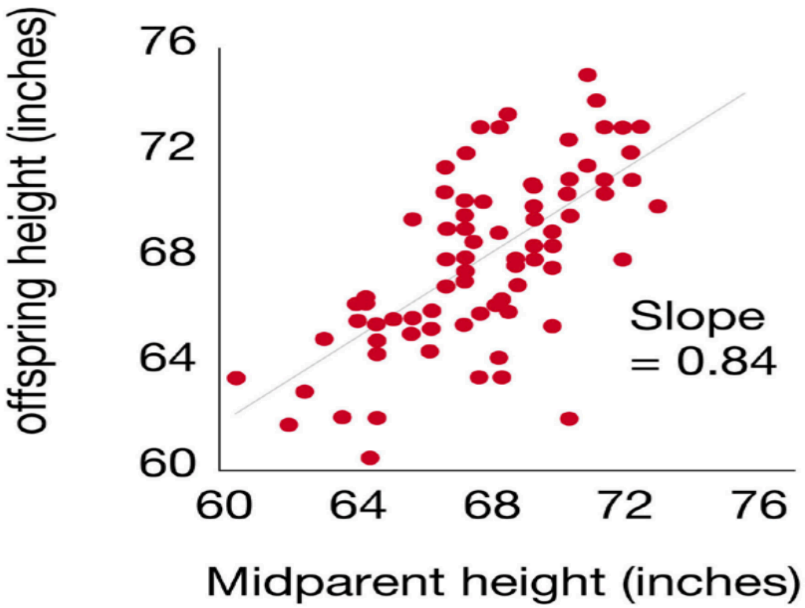

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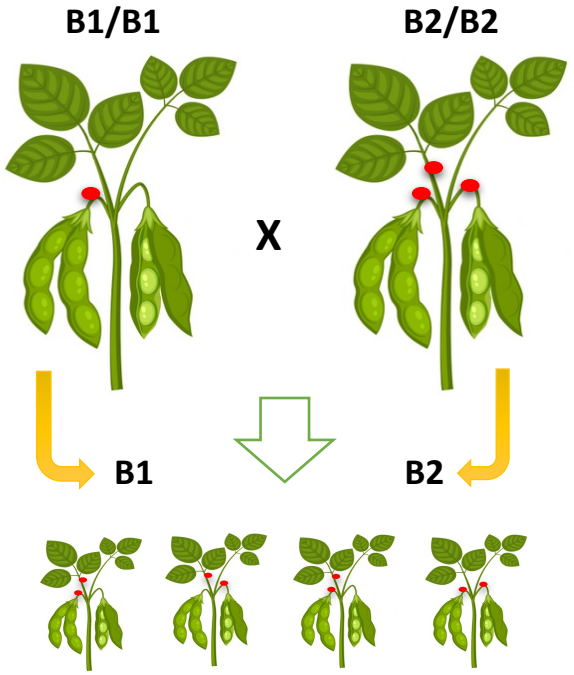

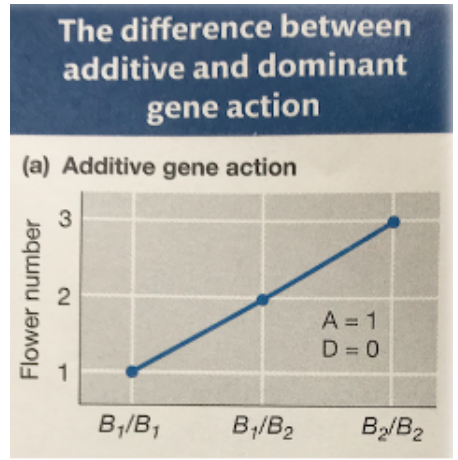

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Griffiths et al 2012

Review

- Quantitative variation: Mean, variance, standard deviation

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \qquad s^2 = \frac{1}{n-1}\sum_{i}(X_i - \bar{X})^2$$

- Genetic model

$$x = g + e$$

- Heritability: Broad and narrow sense

$$H^2 = \frac{Vg}{Vx} \qquad h^2 = \frac{Va}{Vx}$$