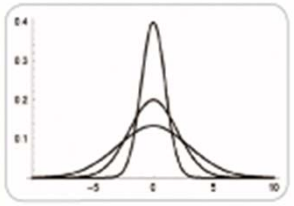
Genes vs. Environment:
How much do each contribute?

Today's lecture
Genes vs. Environment

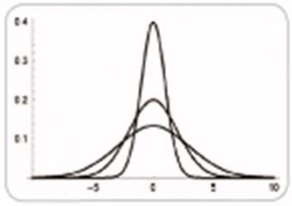
- How do we infer whether each is contributing?
  - Very often both contribute

- **How do we infer their relative contributions?**
  - "Heritability"



“Mean” and “Variance”

- Most traits are variable
- If trait is continuously variable (ie, measurable using a continuous scale), we can calculate a “mean” and a “variance” (spread)



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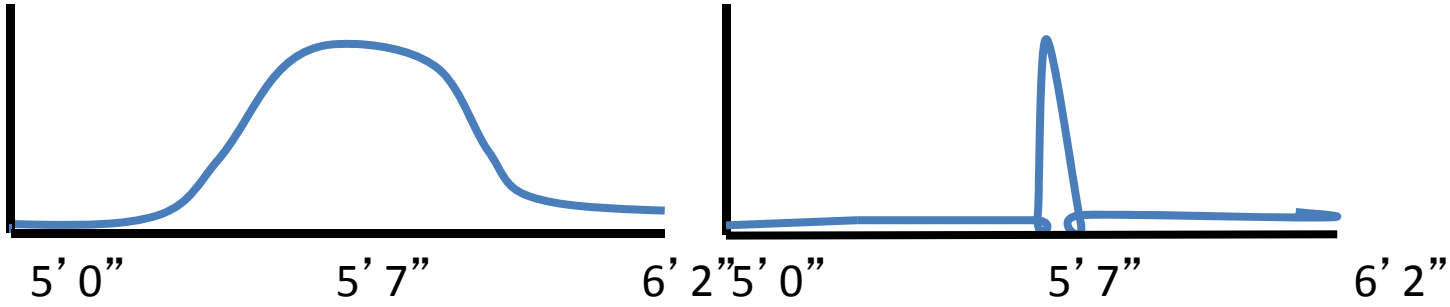
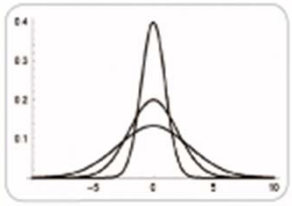
Height in 2 classrooms:

1) What is the mean?
2) Which has more “variance”?



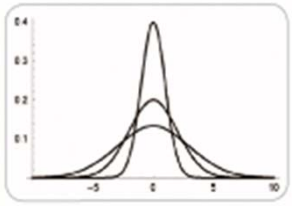


“Mean” and “Variance”

- Mean = “average”
- Variance = how “spread out” individual measures are from the mean
  - Calculated as $\frac{\Sigma(X-\mu)^2}{N}$

    where X is an individual measure, μ is the mean,
    and N is the number of measures

If you had 10 individuals <u>all</u> with a height of 69 inches, what is the mean and what is the variance?



Example

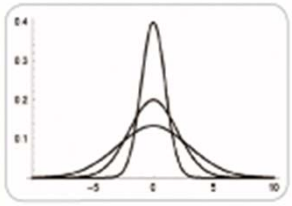
- $\frac{\Sigma(X-\mu)^2}{N}$ = **Variance**

  where X is an individual measure, μ is the mean, and N is the number of measures

1. Heights in inches: 63, 65, 67, 67, 69, 71
2. Heights in inches: 65, 66, 67, 67, 68, 69

Which has greater variance: 1 or 2 or equal?

Try it with and without the math…



Example: answer

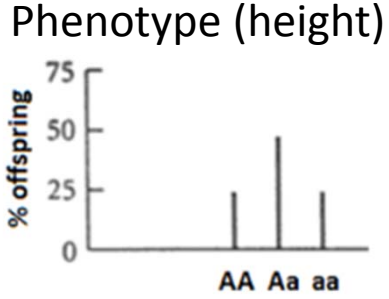
1. Heights in inches: 63, 65, 67, 67, 69, 71
   Mean = (63+65+67+67+69+71)/6 = 402/6 = **67**
   Variance = $((63-67)^2 + (65-67)^2 \ldots)/ 6 = 6.66$ $\frac{\Sigma(X-\mu)^2}{N}$

2. Heights in inches: 65, 66, 67, 67, 68, 69
   Mean = (65+66+67+67+68+69)/6 = 402/6 = **67**
   Variance = $((65-67)^2 + (66-67)^2 \ldots)/6 = 1.66$

What causes the variance in traits like height?

- You see the variance in the **phenotype**
- Some of the variance is **genetic**
- Some of the variance is **environmental**

2 alleles at a single gene control height, and **no** effect of environme



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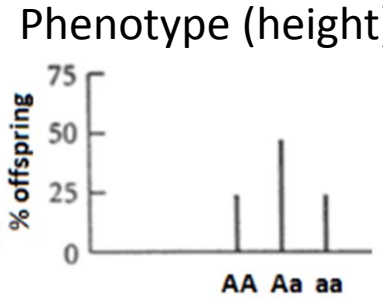

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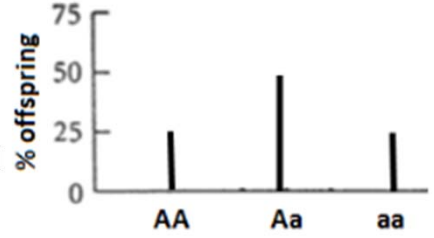
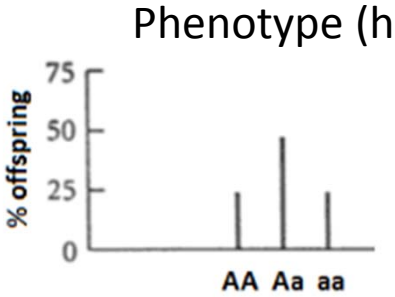


More genetic variance

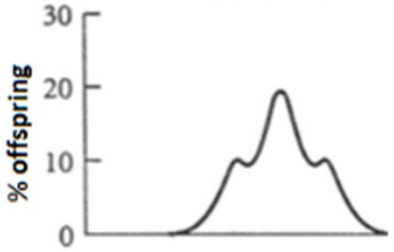
What causes the variance in traits like height?

- You see the variance in the **phenotype**
- Some of the variance is **genetic**
- Some of the variance is **environmental**

2 alleles at a single gene control height, and **no** effect of environme



2 alleles at a single gene control height, and **sor** effect of environment:



Added environmental variance

What causes the variance in traits like height?

- You see the variance in the **phenotype**
- Some of the variance is **genetic**
- Some of the variance is **environmental**

Simple formula: $V_P = V_G + V_E$

V_P = phenotypic variance

V_G = genetic variance

V_E = environmental variance

What causes the variance in traits like height?

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Simple formula: $V_P = V_G + V_E$

V_P = phenotypic variance

V_G = genetic variance

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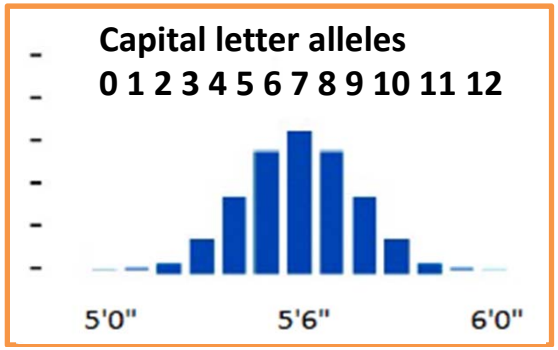
But how to calculate???

Genetic variation becomes apparent in F_2 of crosses: 6 genes for "height"

- Start with AA BB CC DD EE FF (6' tall people) having kids with aa bb cc dd ee ff (5' tall people)
- Offspring all heterozygous (5'6" tall): Aa Bb Cc Dd Ee Ff
- What happens in F2?
  - Aa Bb Cc Dd Ee Ff x Aa Bb Cc Dd Ee Ff :
  - If unlinked, MANY possibilities

SLIDE USED EARLIER…



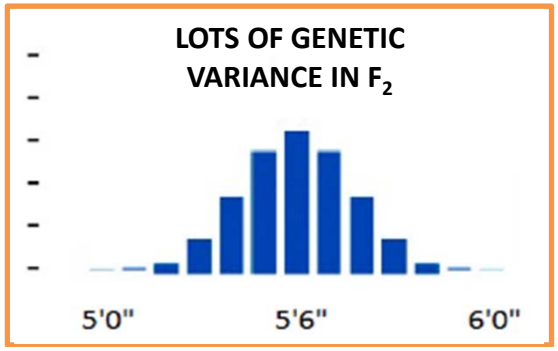
Genetic variation becomes apparent in F_2 of crosses: 6 genes for "height"

AA BB CC DD EE FF x aa bb cc dd ee ff

NO GENETIC VARIANCE IN PARENTALS OR F_1

F_1: Aa Bb Cc Dd Ee Ff

F2:



$V_P = V_G + V_E$

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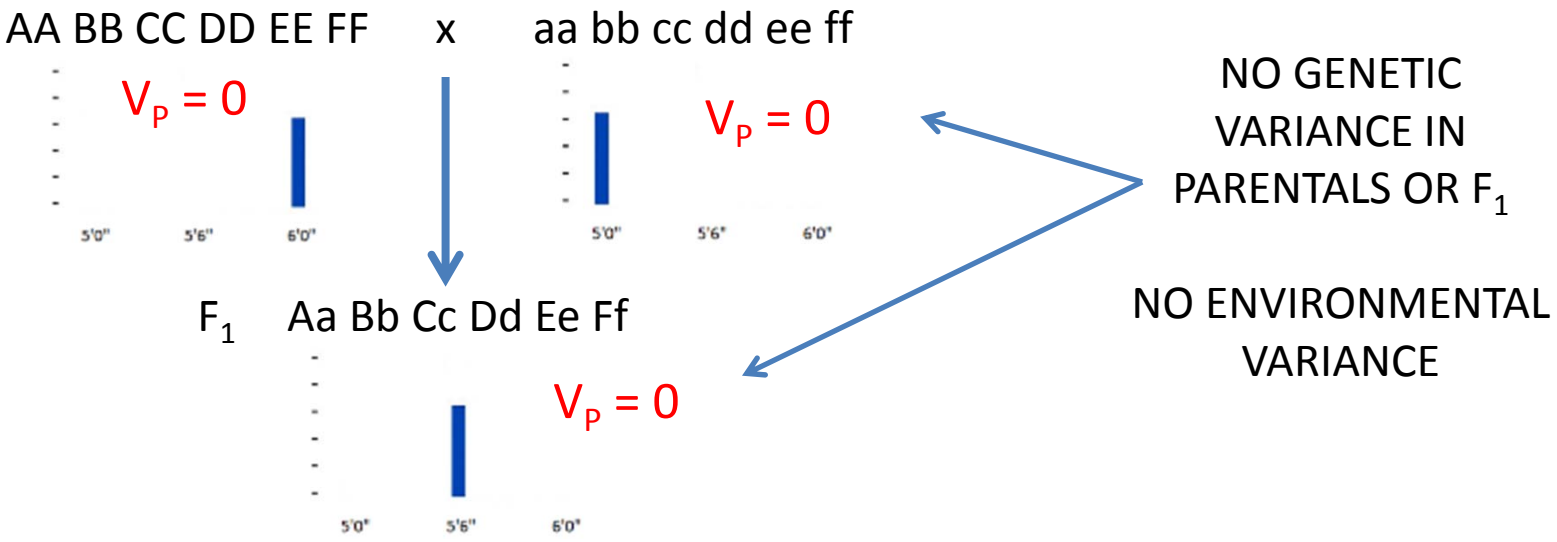

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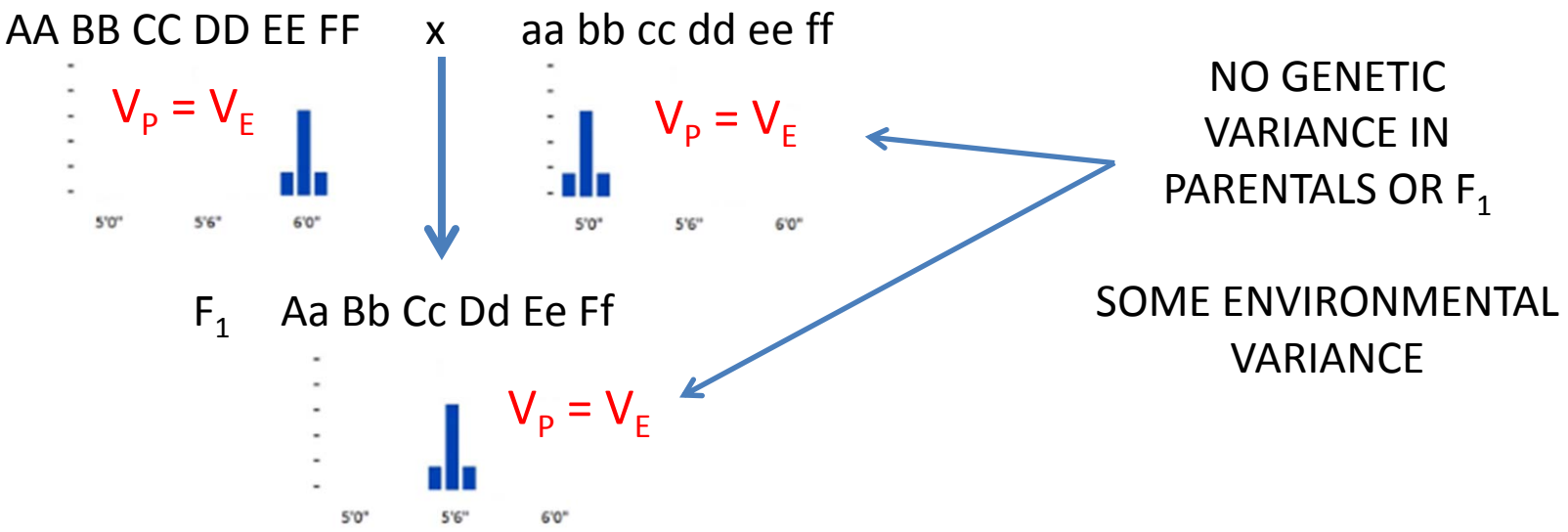

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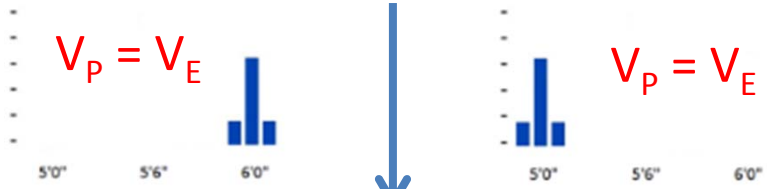
Genetic variation becomes apparent in F_2 of crosses: 6 genes for "height"

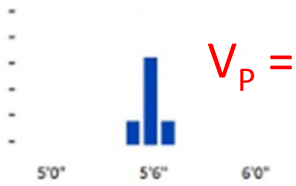
AA BB CC DD EE FF x aa bb cc dd ee ff



$V_P = V_E$ $V_P = V_E$

NO GENETIC VARIANCE IN PARENTALS OR F_1

F_1 Aa Bb Cc Dd Ee Ff

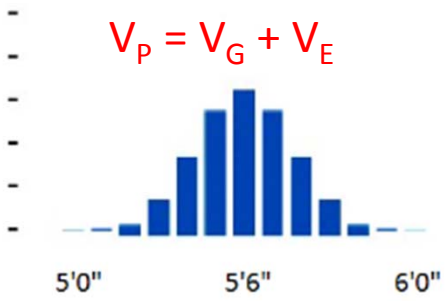


$V_P = V_E$

SOME ENVIRONMENTAL VARIANCE

F_2: $V_P = V_G + V_E$

GENETIC & ENVIRONMENTAL VARIANCE



$V_P = V_G + V_E$

Variance components

$V_P = V_G + V_E$

- We want to know "how much" genetics and environment contribute to phenotypic variance

- Fraction of total phenotypic variance that's genetic is called "Heritability"

  (V_G/V_P) or $(V_G/(V_G+V_E))$

  Ranges 0 (no genetic) to 1 (all genetic)

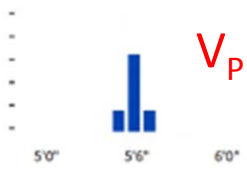
F_2 example to try

TALL PARENT x short PARENT

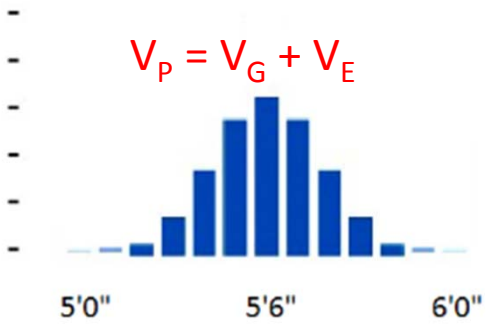
$V_P = V_E$ $V_P = V_E$

F_1 Intermediate

$V_P = V_E$



F2:



$V_P = V_G + V_E$

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Heritability = $V_G/(V_G + V_E)$

EXAMPLE:

Manually calculate variance for F1s to be: 5

Manually calculate variance for F2s to be: 25

What is heritability???