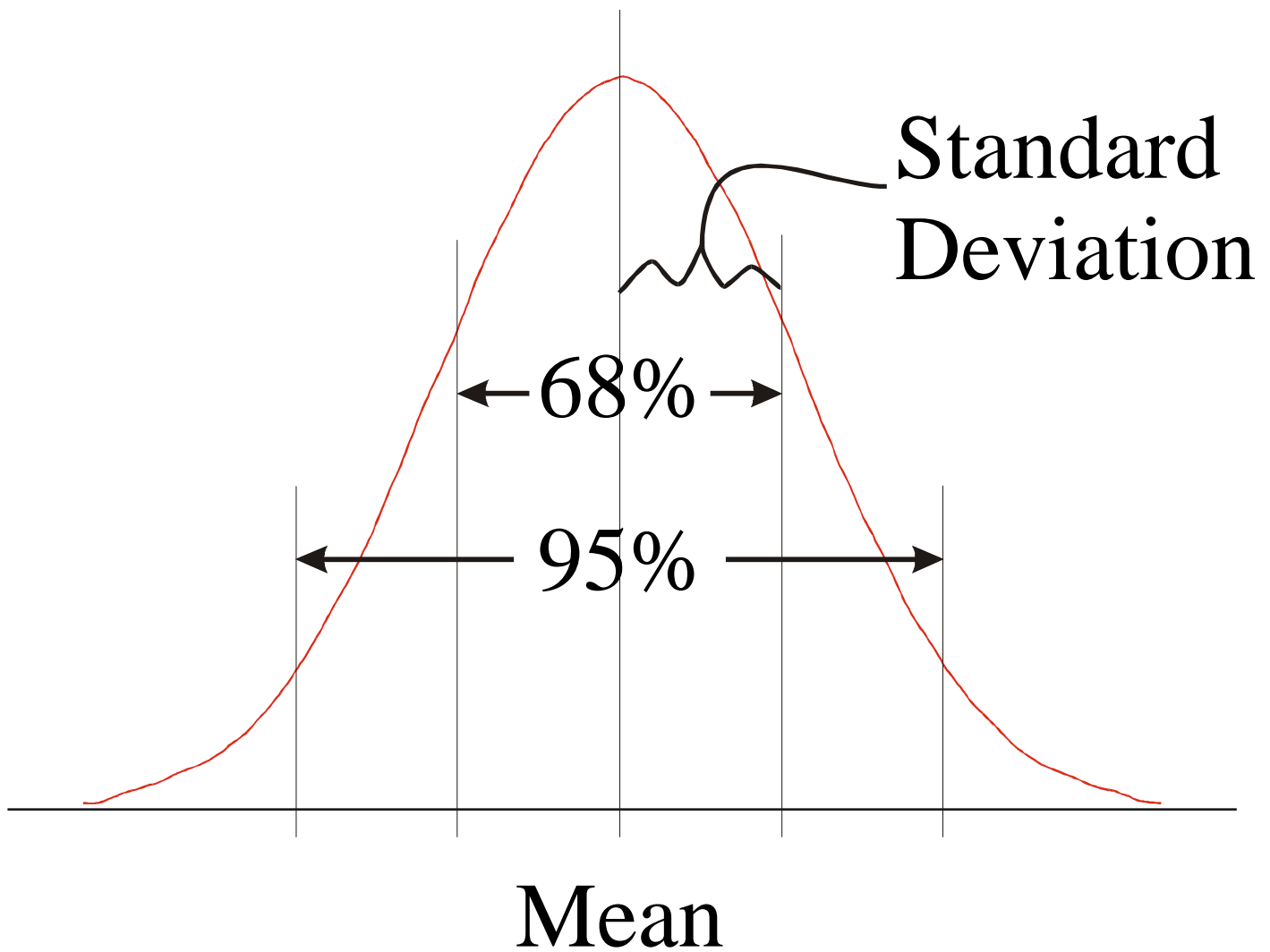


Quantitative Genetics

Normal Distribution



Quantitative Genetics

$$\begin{aligned}\text{Phenotype} = & \text{Genotypic Effect} \\ & + \text{Environmental Effect} \\ & + \text{Genotype - Environment Interaction}\end{aligned}$$

This is essentially unsolvable. Instead, we look at the variation:

$$\begin{aligned}\text{Variance of Phenotypes} = & \text{Variance of Genetic} \\ & \text{Effects} \\ & + \text{Variance of} \\ & \text{Environmental Effects}\end{aligned}$$
$$V(P) = V(G) + V(E)$$

Heritability

Definition:

The fraction of the observed *variation* that is directly attributable to the *variation* of genotypes.

$$\begin{aligned} H^2 &= V(G) / V(P) \\ &= V(G) / [V(G) + V(E)] \end{aligned}$$

Heritability High

$V(G)$ Relatively Large

$V(E)$ Relatively Small

Phenotypic Selection for this population will be effective.

Management changes, **within the range of environments**, may not be effective.

Heritability Low

$V(G)$ Relatively Small

$V(E)$ Relatively Large

Phenotypic Selection for this population will not be effective.

Management changes, **within the range of environments**, may be effective.

Heritability

What Heritability is NOT

- w Heritability **does not** measure the amount that genes are involved in a trait.
- w Heritability **does not** measure the relative importance of genes and environments for a trait.
- w Heritability **is not** an immutable part of the species.
- w Heritability **does not** involve *just* the genes.
- w Heritability **is not** the same for *all* traits for a population.
- w Heritability **is not** a statement about individuals.

Examples: Heritability

What is the heritability?

A researcher is studying field mice. She has two populations, reared in the same mouse facilities at the Vet School. One population is a colony of “wild” field mice (agouti coloring). The other population is a colony of albino field mice (white coloring).

- w What is the heritability of coat color for the wild mice?
- w What is the heritability of coat color for the albino mice?
- w Is the difference between coat color for the two populations genetic or environmental?

Examples: Heritability

What is the heritability?

A researcher is studying the flower color for a type of columbine. He is using the Phytotron's growth chambers to control environmental factors. He has collected from a wild population over a broad area. For his experiment, he grows one half of the seeds in a growth chamber with low pH. The other half he grows in a growth chamber with high pH.

- w What is the heritability of flower color for the low pH plants?
- w What is the heritability of flower color for the high pH plants?
- w Is the difference between flower color for the two populations genetic or environmental?

General Rules: Heritability

- w Measures **Variability**. If no genetic variability, then heritability is very low. If no environmental variability, then heritability is very high.
- w Cannot be used to compare two populations unless:
 - { The populations are randomly chosen from the same superpopulation.
 - Or
 - { The environments are the same.
- w Can be manipulated by changing:
 - { Genetic variability [through, *e.g.*, induced mutation (increases variability) or inbreeding (decreases variability)]
 - { Environmental variability (through, *e.g.*, controlled environmental conditions)

Narrow Sense Heritability

Broad Sense Heritability

$$H^2 = \text{Var}(G)/\text{Var}(P)$$

Measures **all** nuclear genetic sources

Narrow Sense Heritability

$$h^2 = \text{Var}(A)/\text{Var}(P)$$

Var(A) is the additive genetic variance (statistical)

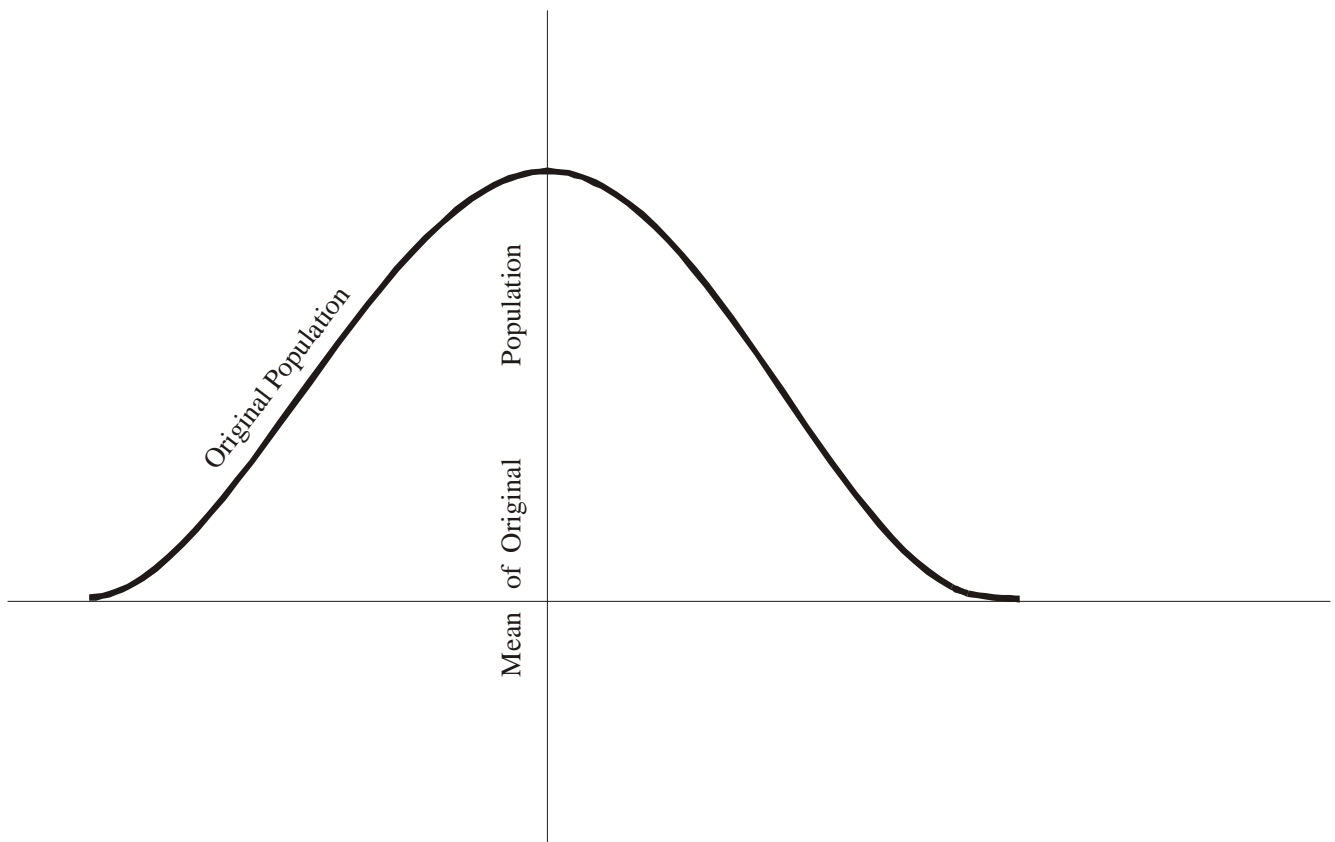
Useful in understanding selection experiments.

Mass Selection

The Problem

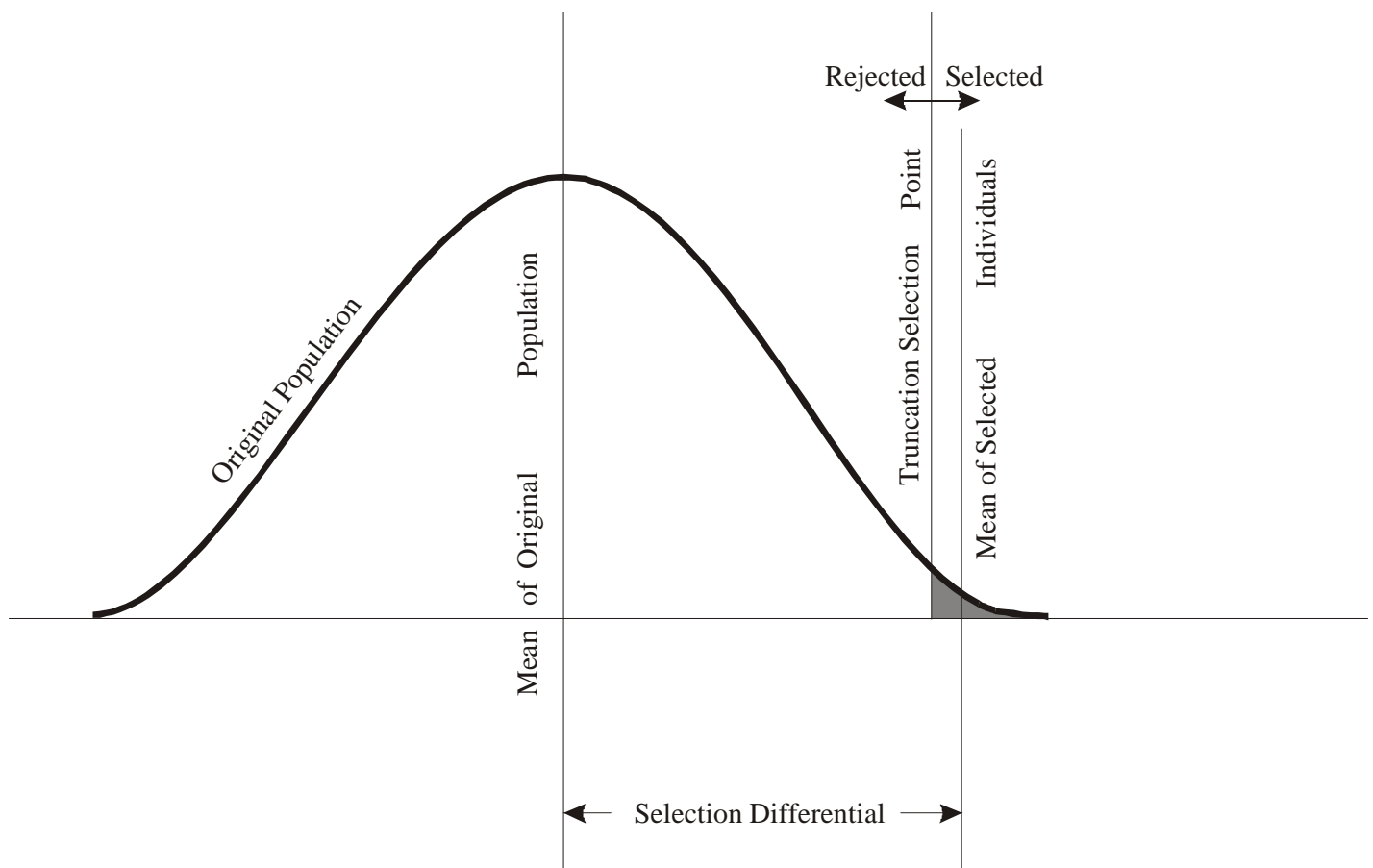
We are interested in increasing some quantitative trait through selective breeding.

For our population, the distribution of the trait looks like:



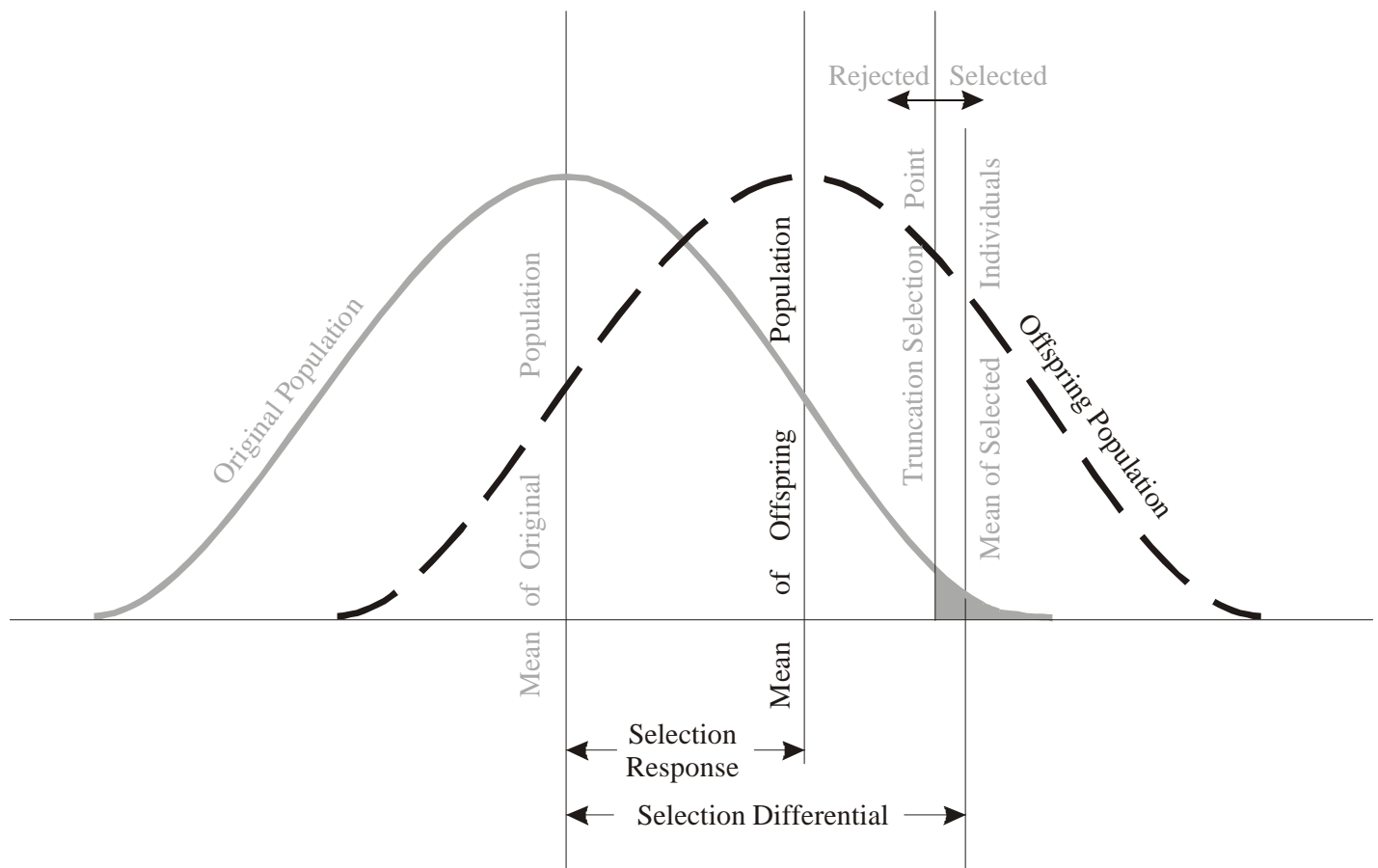
Mass Selection: The parents

From this population, we will choose the top individuals to be the parents for our selection experiment. We will choose the top **p** (a fraction, with smaller values representing more intense selection). This looks like:



Mass Selection: The offspring

The offspring from the selected parents are then scored. If there is some genetic variability, then we would expect some “progress from selection.” This is shown in the next chart:



Mass Selection: An example

The following table is useful in Mass Selection Problems:

Proportion Selected (p)	0.5	0.25	0.1	0.05	0.01
Selection Intensity (I)	0.8	1.27	1.76	2.06	2.67
Standardized Selection Point (Z)	0	0.67	1.28	1.65	2.33

These are from a **Standard Normal Distribution** (Normal Distribution with mean zero and standard deviation one).

Example:

We are interested in increasing the yield of dill in our kitchen garden. The mean yield per plant is 60ml, with a standard deviation of 2.3ml. We will select the top 5% in a mass selection scheme.

Mass Selection Example: Continued

Proportion Selected (p)	0.5	0.25	0.1	0.05	0.01
Selection Intensity (I)	0.8	1.27	1.76	2.06	2.67
Standardized Selection Point (Z)	0	0.67	1.28	1.65	2.33

Mean = 60ml

Std. Dev. = 2.3ml

$h^2 = 0.45$

$p = 0.05$

Selection Differential = $(2.06)(2.3\text{ml}) = 4.738\text{ml}$

Truncation Point = $(1.65)(2.3\text{ml}) + 60\text{ml} = 63.795\text{ml}$

Selection Response = $(0.45)(4.738\text{ml}) = 2.1321\text{ml}$

Expected Mean of Offspring = $60\text{ml} + 2.1321\text{ml} = 62.1321\text{ml}$