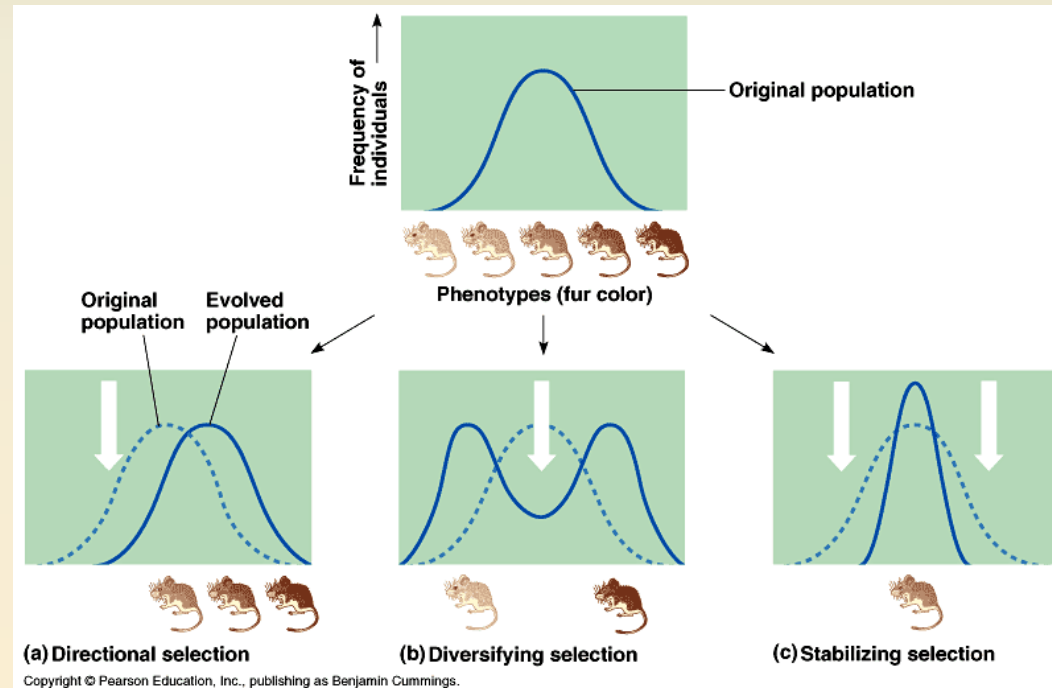
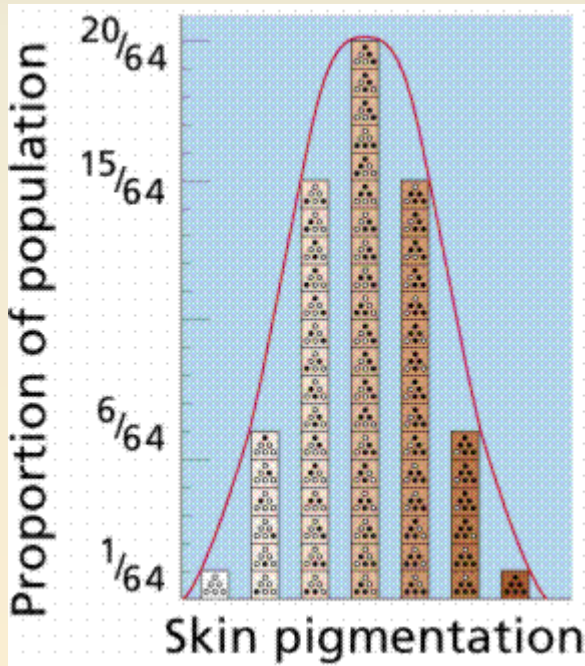
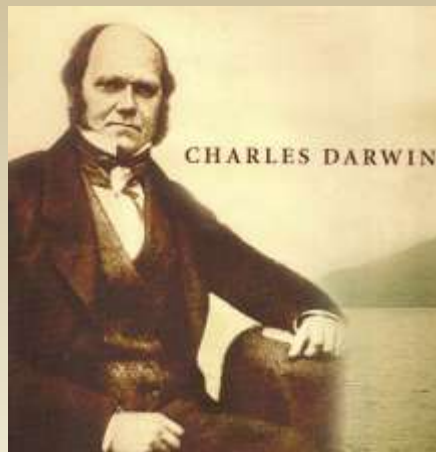


Quantitative Traits

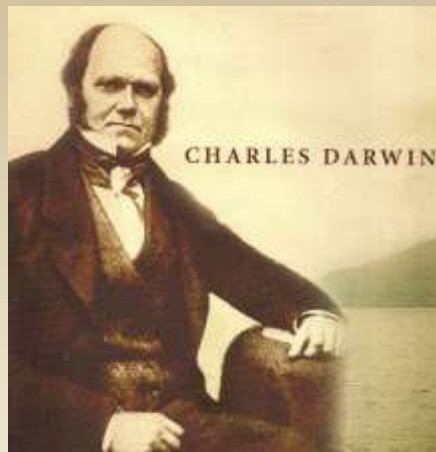
Modes of Selection





**“Preservation of Favored
Races in the Struggle for Life”
= Natural Selection**

1. There is **variation** in morphology, function or behavior between individuals.
2. Some traits are more **adaptive** than others.
3. Traits are **heritable**.
4. Individuals that are more "**fit**" live to reproduce or **reproduce more**.
5. Less adaptive traits become less common in populations



**“Preservation of Favored
Races in the Struggle for Life”
= Natural Selection**

If there is heritable variation among the individuals of a population, and if there are differences in survival and/or reproductive success among the variants, then the populations will evolve.

Neo-Darwinists - 1920s

Ronald Fisher, J.B.S. Haldane, Sewall Wright

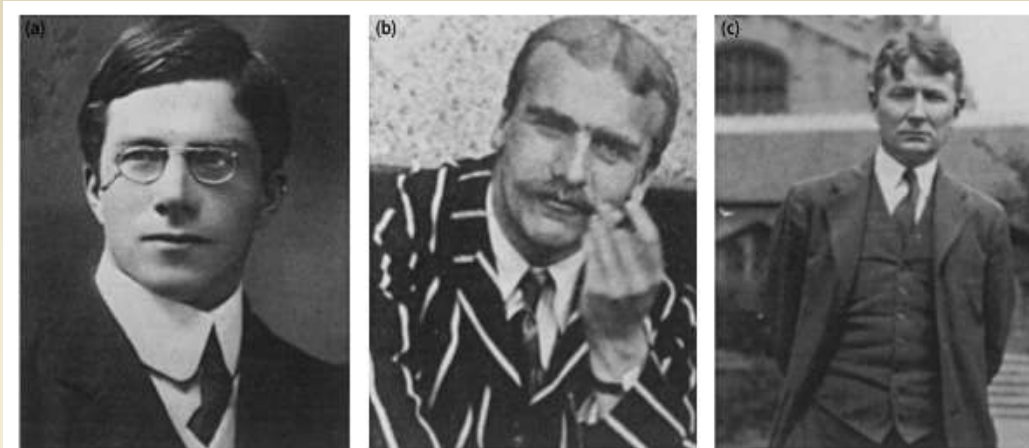


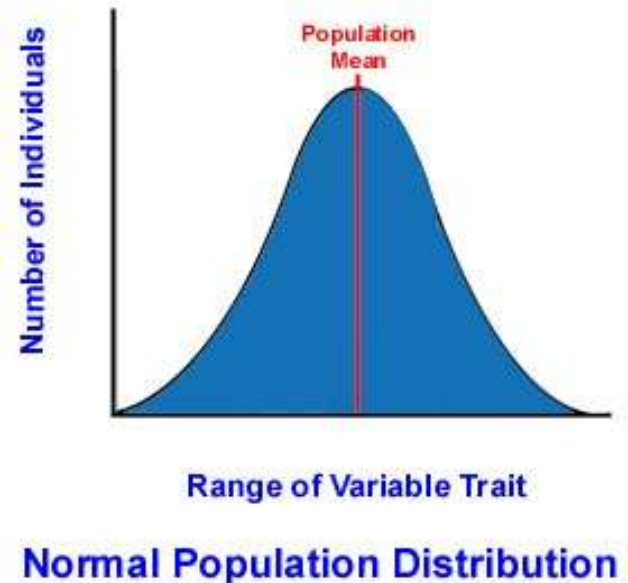
Figure 1.8

(a) Ronald Aylmer Fisher (1890–1962) in 1912, as a Steward at the First International Eugenics Conference.

(b) J.B.S. Haldane (1892–1964) in Oxford, UK in 1914.
(c) Sewall Wright (1889–1988) in 1928 at the University of Chicago.

Shift in emphasis from individuals to populations

Worked out the statistical foundation of population genetics



Simply Inherited and Polygenic Traits

Simply inherited traits: traits affected by **one or few genes** (coat color, presence of horns, shape of seed in garden pea,).

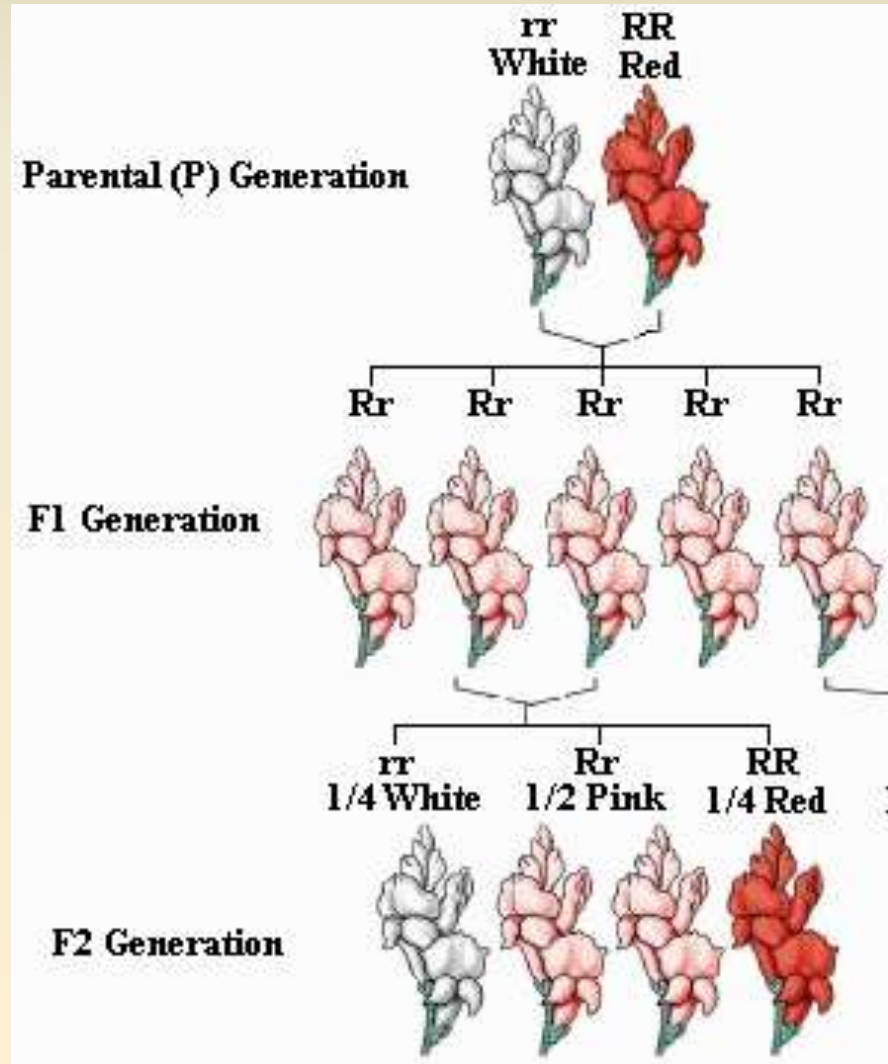
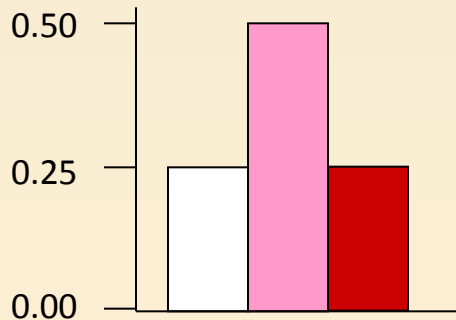
Phenotypes of simply inherited traits are placed into categories (qualitative or categorical or discontinuous traits)

Not affected or very little affected by the environment.

Simple Inheritance

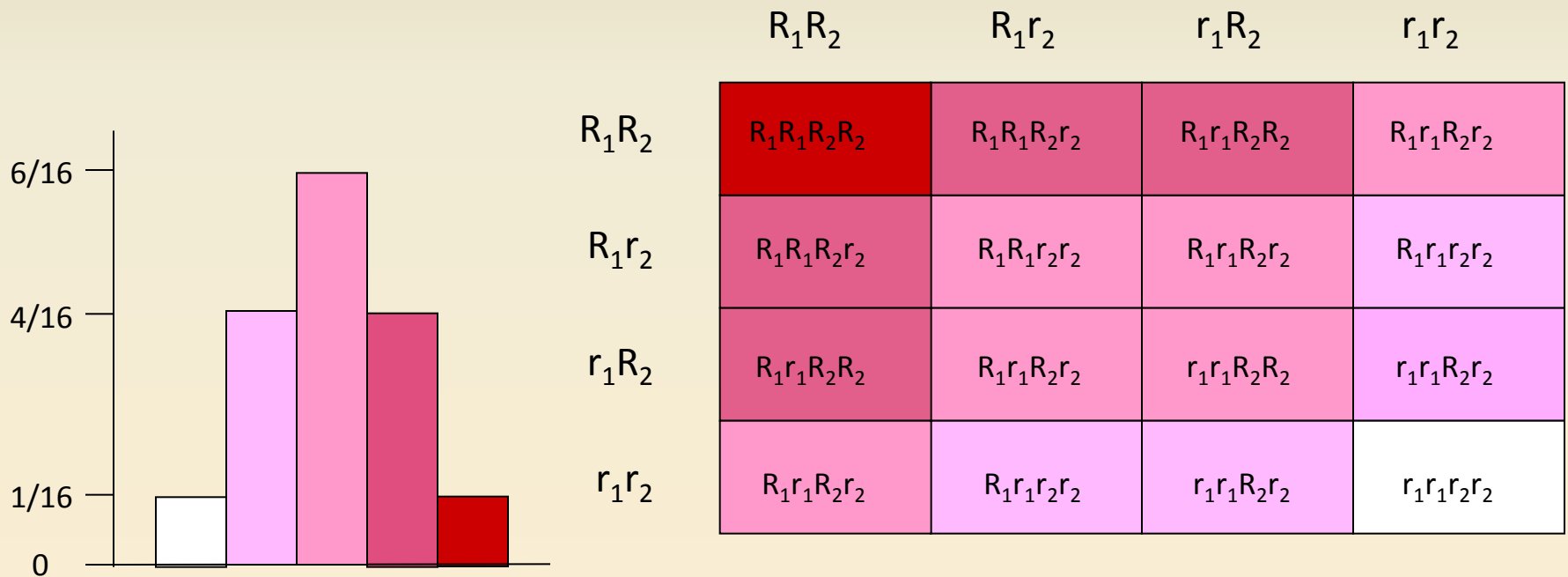
How can discrete alleles be the basis of continuous variation?

Snapdragons – incomplete dominance for flower color



Polygenic Inheritance

How can discrete alleles be the basis of continuous variation?

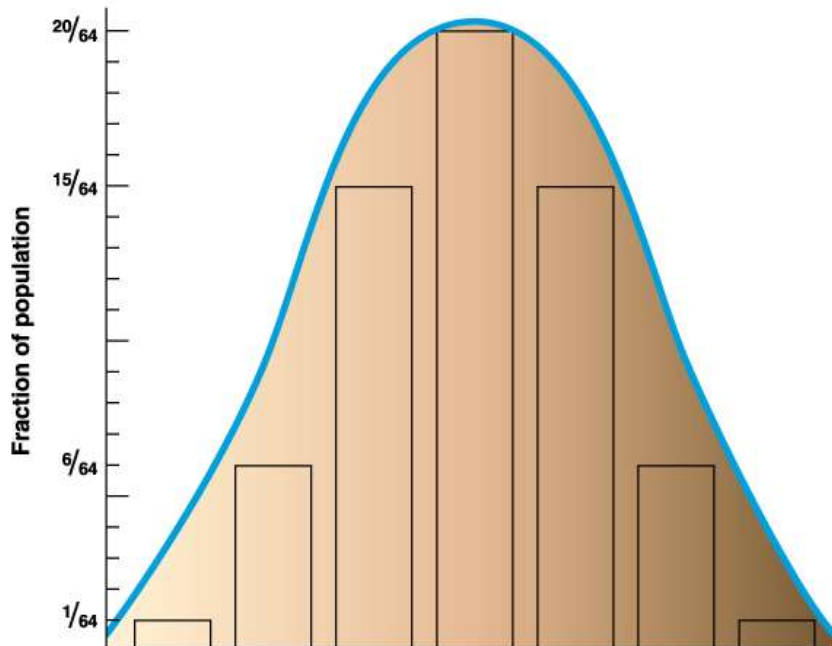
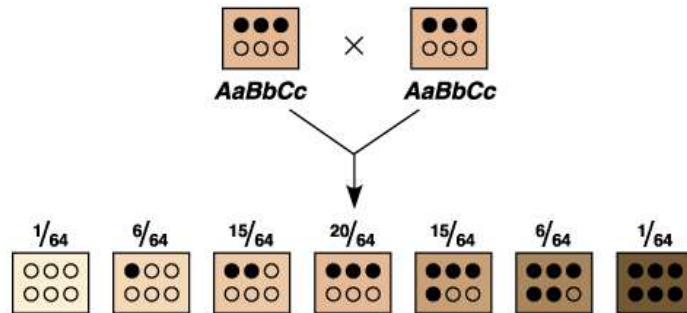


Additive – each R allele adds the same amount to the phenotype

R = “+” r = “0”

Polygenic Inheritance

Human skin color - at least 3 loci that affect the production of melanin



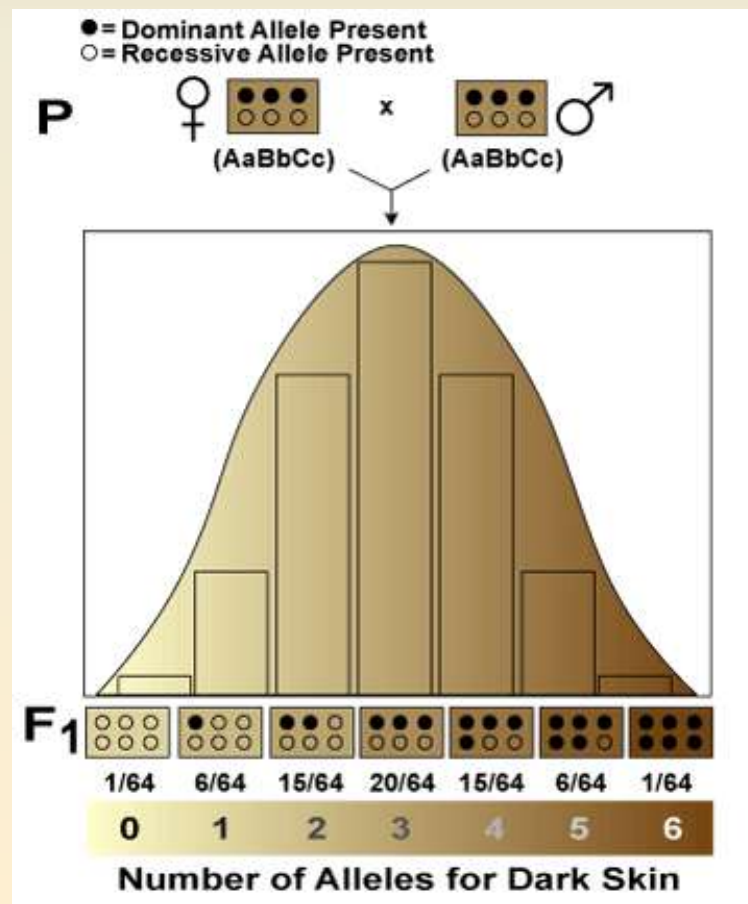
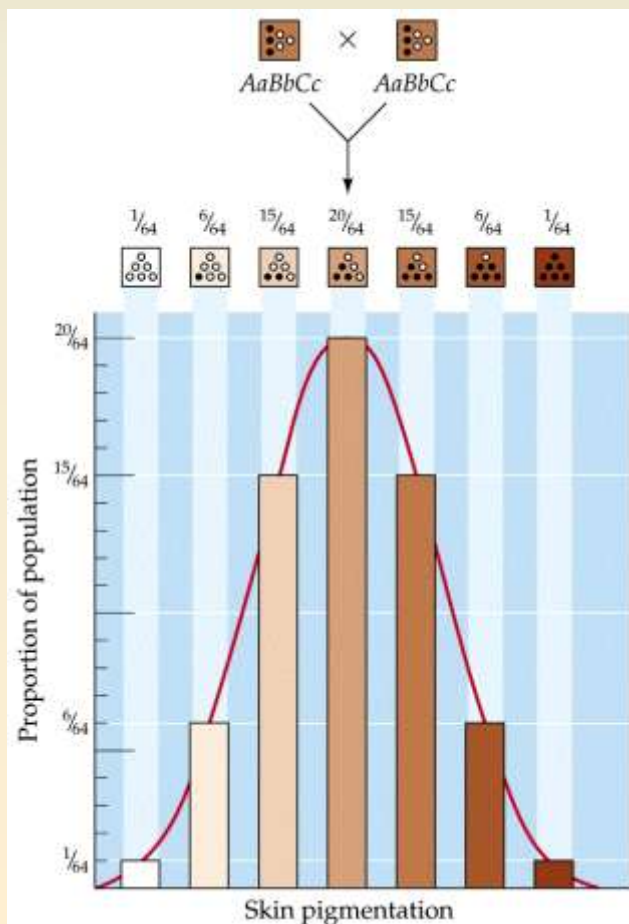
Polygenic trait – based on more than one gene (locus)

Polygenic Inheritance

Polygenic inheritance is a characteristic showing continuous variation and is controlled by the alleles of more than one gene

The more genes involved the more intermediate phenotypes that can be produced

The effects of the genes are **additive** (each dominant allele of each gene adds a contribution towards the characteristic controlled by the gene)



Polygenic Inheritance

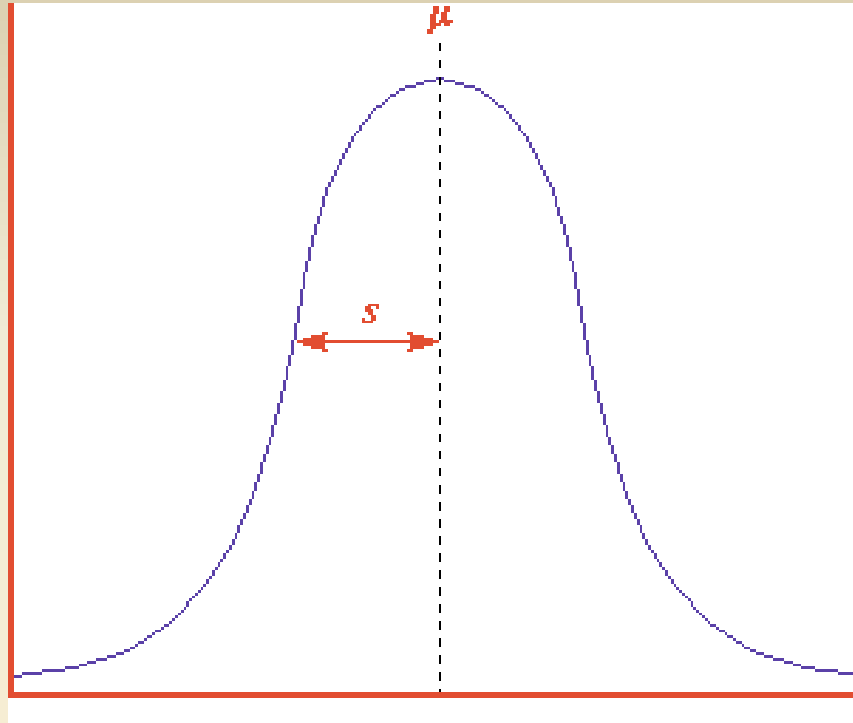
Generally described in numbers.

Typically quantitative or continuous in their expression (quantitative or continuous traits)

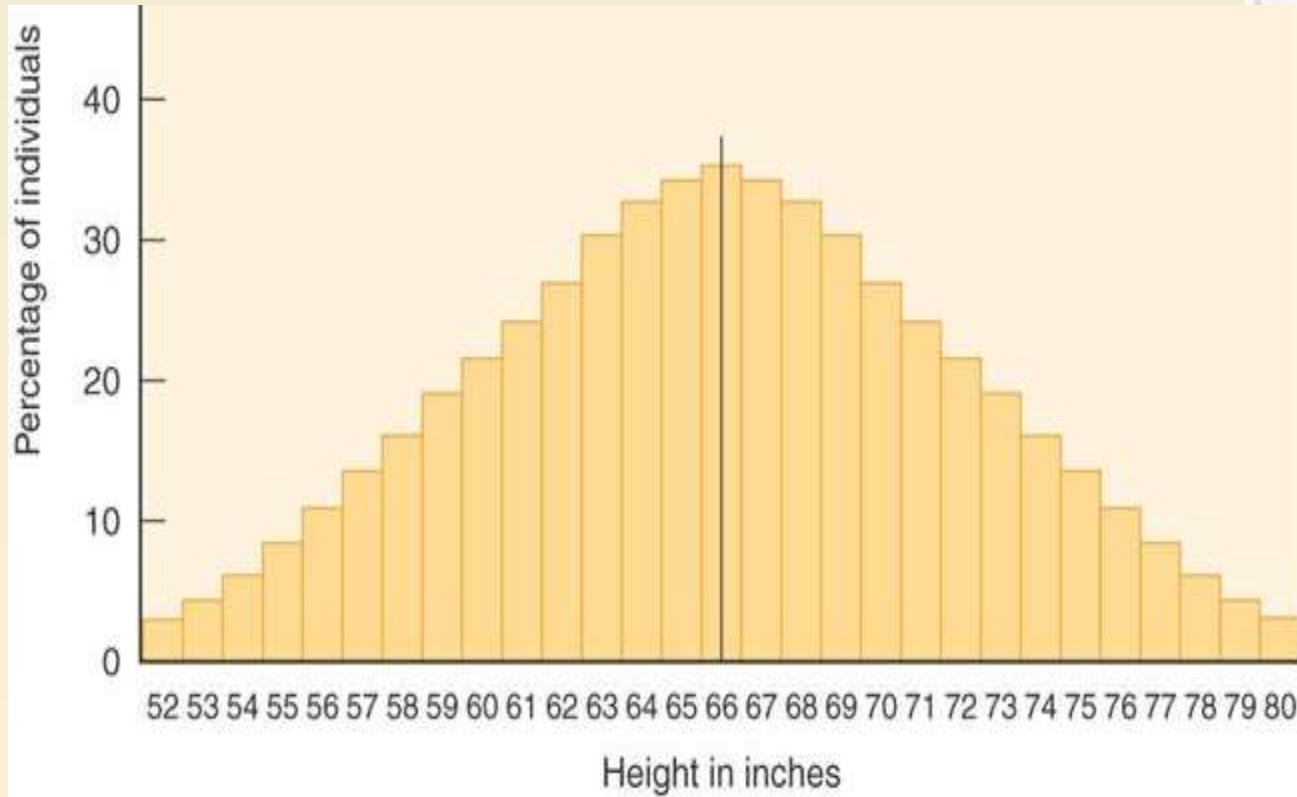
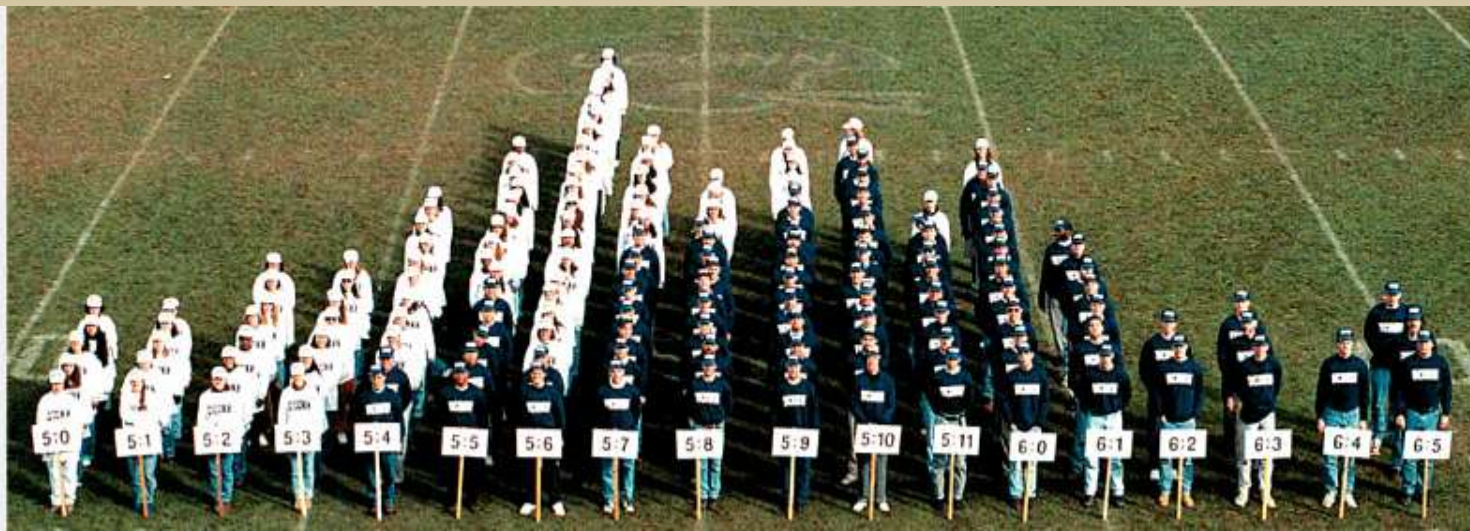
Polygenic traits are affected by the environment.

They generally have a normal distribution

Normal Distribution

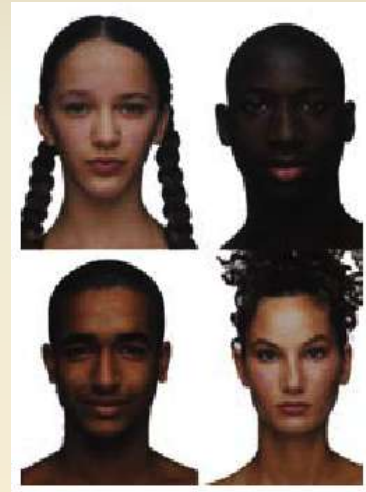


In general, the distribution of quantitative traits values in a population follows the **normal distribution** (also known as Gaussian distribution or bell curve). These curves are characterized by the **mean (mid-point)** and by the **variance (width)**. Often standard deviation, the square root of variance, is used as a measure of the curve's width.

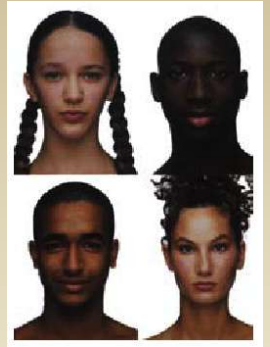


Some quantitative phenotypic traits that evolved along the human lineage, or in some populations

- (1) Large brain size
- (2) Light skin color
- (3) Altriciality at birth
- (4) Longer juvenile period
- (5) Smaller teeth
- (6) Relative hairlessness
- (7) Increased susceptibility to cancer, heart disease
- (8) Language skills, technical skills



Some of the big questions of quantitative genetics analysis



1. How do genetics and the environment affect a trait?
2. Which and how many genes produce a set of phenotypes for a trait; where in the genome are they located?
3. Do some genes play a major role, whereas other genes modify or play a small role?
4. How does selection affect the trait? What form of selection?

Quantitative Genetics: is the science which deals with the inheritance of quantitative traits.

Quantitative genetics allows us to measure the degree to which variation in a trait is heritable (and therefore can respond to selection).

We can also measure the strength of selection

Combining heritability and strength of selection allows us to predict evolutionary change in response to selection.

Quantitative Trait Loci – QTLs

Portion of a genome that influence quantitative traits.

Identify QTLs by identifying co-inheritance of specific genetic marker alleles (such as Single Nucleotide Polymorphism or microsatellites) with the phenotypic trait

QTLs are identified by genetic mapping using DNA markers.

Quantitative variation is based on both genetic and environmental variation



low nutrient environment



high nutrient environment

genetically similar individuals
(clone, inbred line, siblings,
monozygotic twins)

Evidence: lack of
resemblance
between relatives.
If some individuals
get more food they
grow larger

The basic model for quantitative traits

$$P = G + E$$

P = phenotypic value for the trait of one individual (plant or animal).

G = the effect of the genes carried by the individual (genotypic value).

E = the effect of the environmental factors on the phenotype of the animal.

Effect of Environment

Many characteristics which show continuous variation (e.g. height, foot size, etc.) are influenced by the environment

They are dependant on favourable environmental conditions for their full phenotypic expression.

For example, regardless of how many dominant alleles for height that a person inherits, he or she will not reach their full potential for height without consuming an adequate diet during childhood and adulthood.

Heritability (Simplified)

Heritability in the broad sense (H^2): is the proportion of the total phenotypic variance that is due to all genetic effects (additive, dominance and epistasis):

$$H^2 = \frac{V_G}{V_P}$$

Variation due to genetics

Total phenotypic variation

Genetics + Environment

It measures the strength of the relationship between the phenotypic values of the individuals and their genotypic values.

Heritability means that offspring should resemble their parents and relatives

Heritability in the narrow sense (h^2): is the proportion of the phenotypic variance that is due to additive genetic effects only.

$$h^2 = \frac{V_A}{V_P}$$

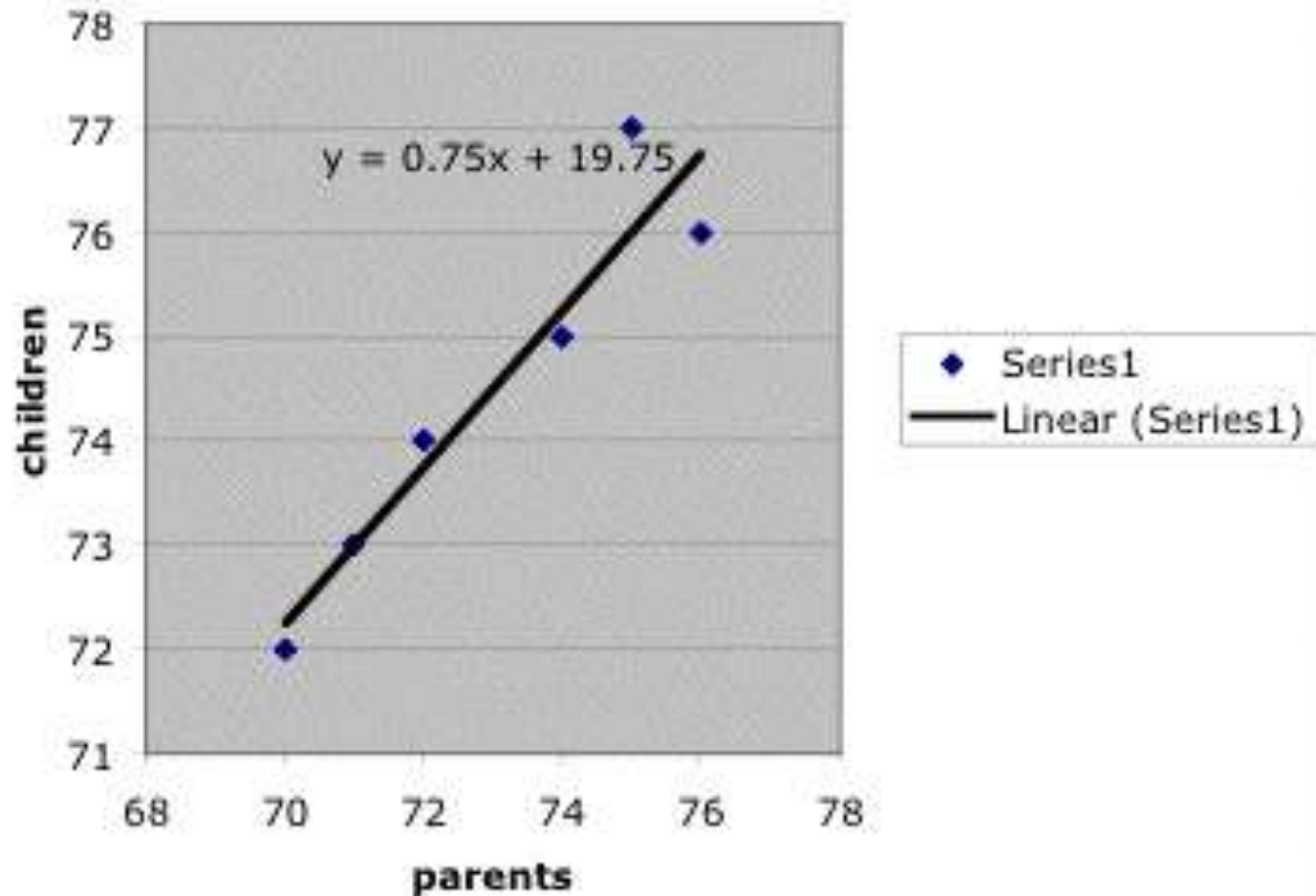
It measures two things:

1. The degree to which the offspring resemble their parents in the phenotype for a trait.
2. The strength of the relationship between the phenotypic values and the additive genetic effects (the relationship between P and A).

Estimating Heritability

- (1) Analyze related individuals: twins of different type, or parents and offspring
- (2) Measure the response of a population, in the next generation, to selection

Heritability of Height



The slope of the regression line is .75, which indicates high heritability.

Parents and Children - about 50% shared genes



John and Julian Lennon

Measuring heritability from analysis of DZ and MZ twins



Monozygotic (MZ) twins: one egg twins genetically identical (100% of genes in common)

Dizygotic (DZ) twins: two egg twins, same degree of genetic relatedness as normal siblings (50% of genes in common)

If heritability is high, MZ twins should be more similar (in behavior , height, IQ, autism etc.)

Monozygotic Twins

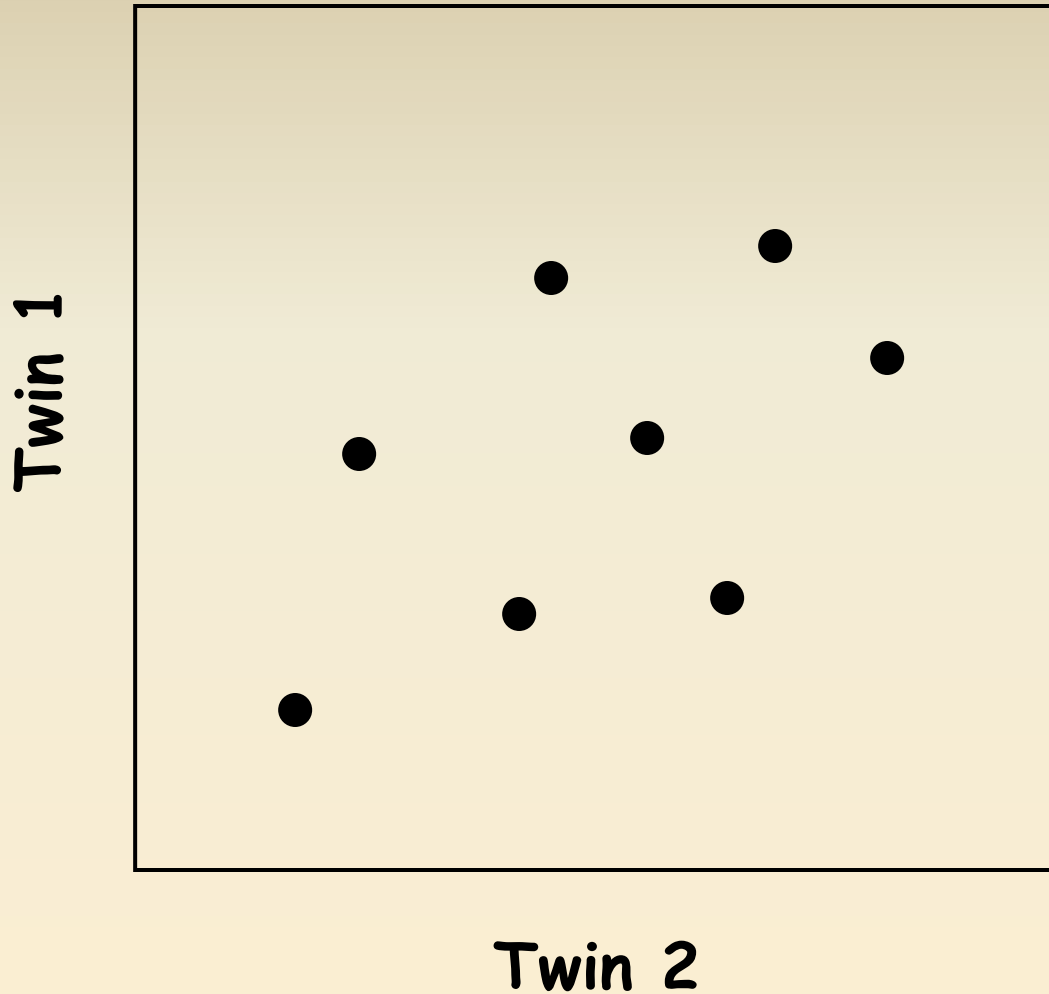


Dizygotic Twins

Kiefer and Rachel Sutherland

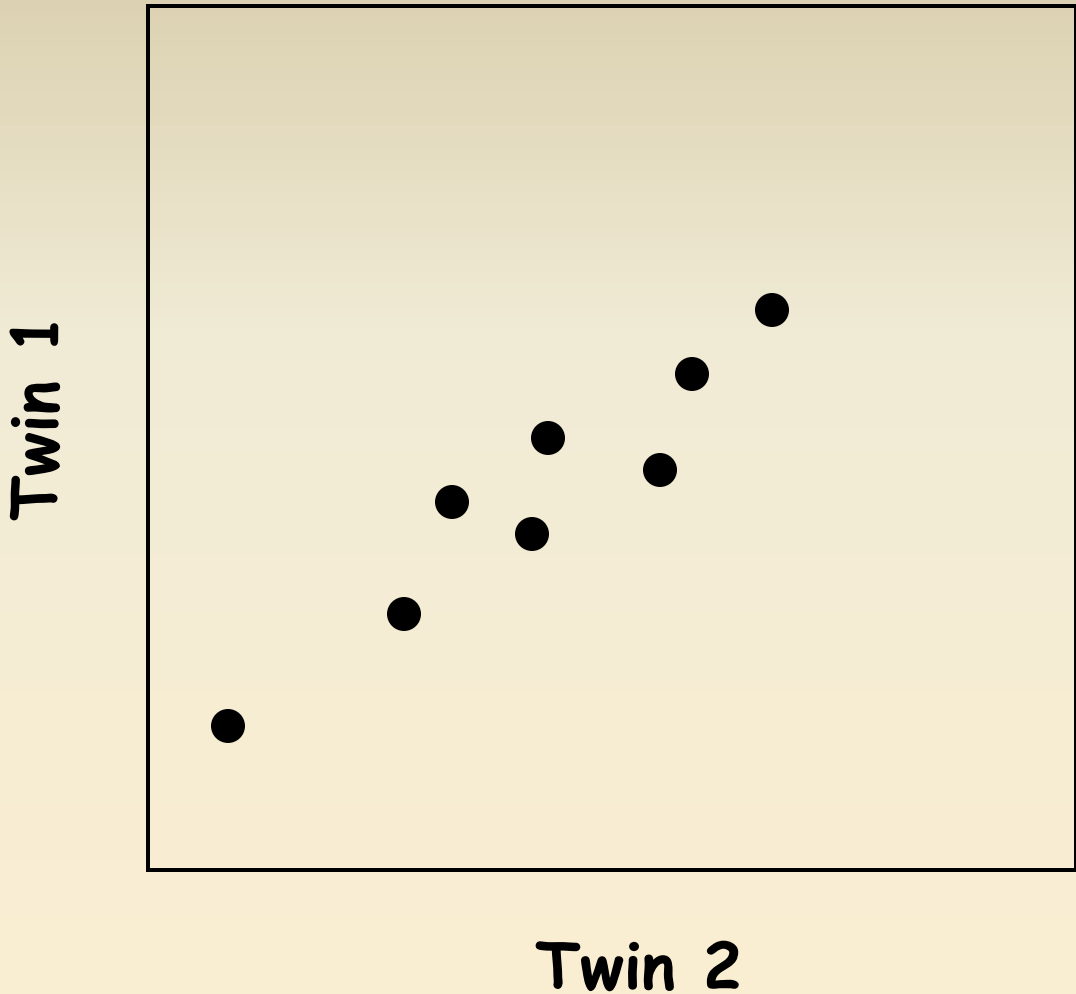


Trait Correlation



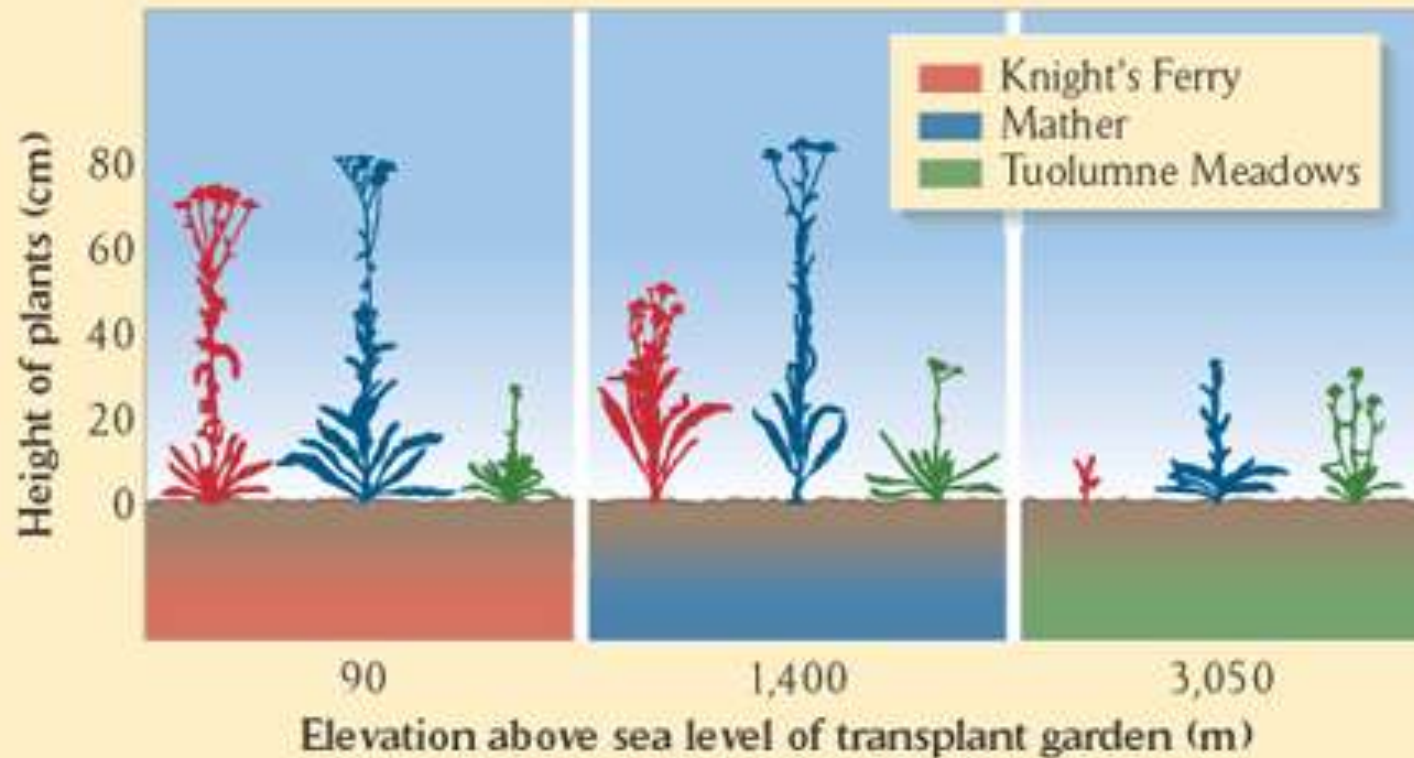
DIZYGOTIC TWINS – loose correlation

CORRELATION



MONOZYGOTIC TWINS - tight correlation

Common Garden Experiment



Reaction norms of plant height in individuals of yarrow *Achillea millefolium* grown from seed obtained at low-, mid-, and high-elevation sites in California and raised in transplant gardens at three elevations.

Clausen, Keck, Heisey, 1948

Heritability of different human traits

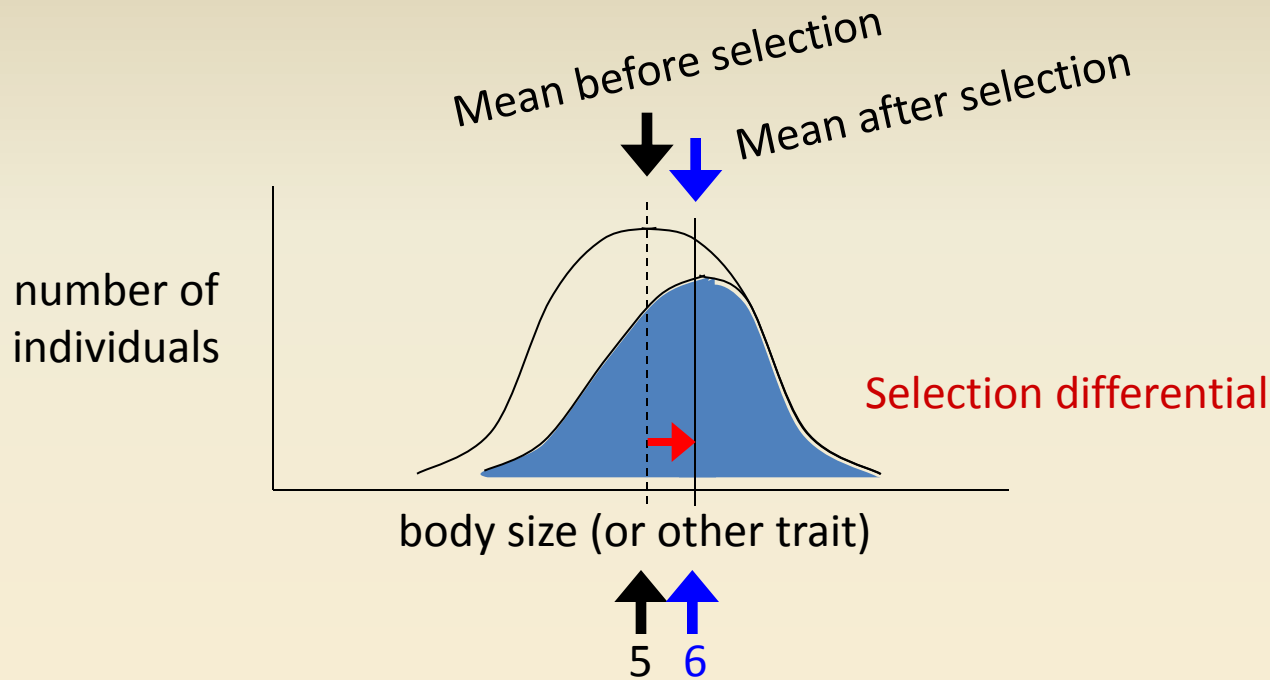
0 – 1 (low to high)

TRAIT	HERITABILITY
Fingerprint pattern	>0.9
Height	0.7
IQ	0.7
Triglyceride	0.7
Autism, schizophrenia	0.3-0.6
Weight	0.5
Cholesterol level	0.45
Blood pressure	0.4
Handedness	0.3
Fertility	0.1

HERITABILITIES FOR SOME TRAITS IN ANIMAL SPECIES

	<u>h^2 (%)</u>
<i>Man</i>	
Stature	65
Serum immunoglobulin (IgG) level	45
<i>Cattle</i>	
Body weight (adult)	65
Butterfat, %	40
Milk-yield	35
<i>Pigs</i>	
Back-fat thickness	70
Efficiency of food conversion	50
Weight gain per day	40
Litter size	5
<i>Poultry</i>	
Body weight (at 32 wks)	55
Egg weight (at 32 wks)	50
Egg production (to 72 wks)	10
<i>Mice</i>	
Tail length (at 6 wks)	40
Body weight (at 6 wks)	35
Litter size (1st litters)	20
<i>Drosophila melanogaster</i>	
Abdominal bristle number	50
Body size	40
Ovary size	30
Egg production	20

Quantifying Selection - Selection Differential



S = mean trait value of selected individuals - mean trait value before selection

$$S = 6 - 5 = 1$$

Response to selection



Measure response to
artificial selection

Response to Selection = R

$R = H \times \text{Selection Differential}$

Importance of Heritability

Measures the degree to which variation in a quantitative trait can be passed from parent to offspring; how well parent's trait predicts offspring's trait

Heritability is very important in selection (in genetic improvement of crops and breeds)

It determines if phenotypic selection would be efficient or not:

- Small heritability: phenotypic selection is not efficient (low accuracy of selection).
- High heritability: phenotypic selection is efficient (high accuracy of selection)

Selection



“This preservation of favourable individual differences and variations, and the destruction of those that are injurious, I have called Natural Selection....”

Charles Darwin

The Origin of Species 1859

Remember the idea....

....more organisms born than can survive and reproduce

....variation among individuals in the population

....some of this variation is heritable

....variation in form leads to variation in survival.

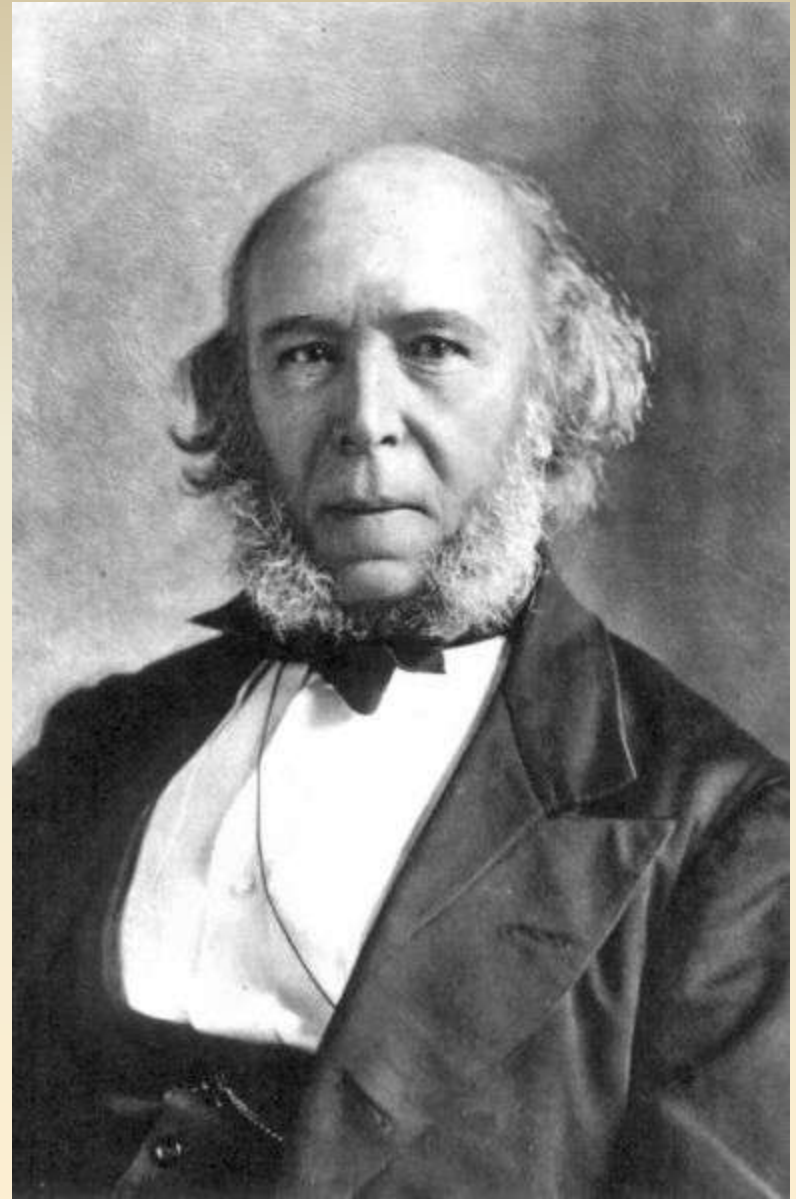
Therefore, over generations, the population changes in response to the environment.

Some call it “survival of the fittest”.

Darwin called it natural selection.

The term “survival of the fittest” was actually introduced by Herbert Spencer in a biology text he wrote in 1864 (after reading Darwin).

It’s important to note that “survival” alone isn’t enough to lead to adaptation. Evolutionary success requires reproduction.



Herbert Spencer

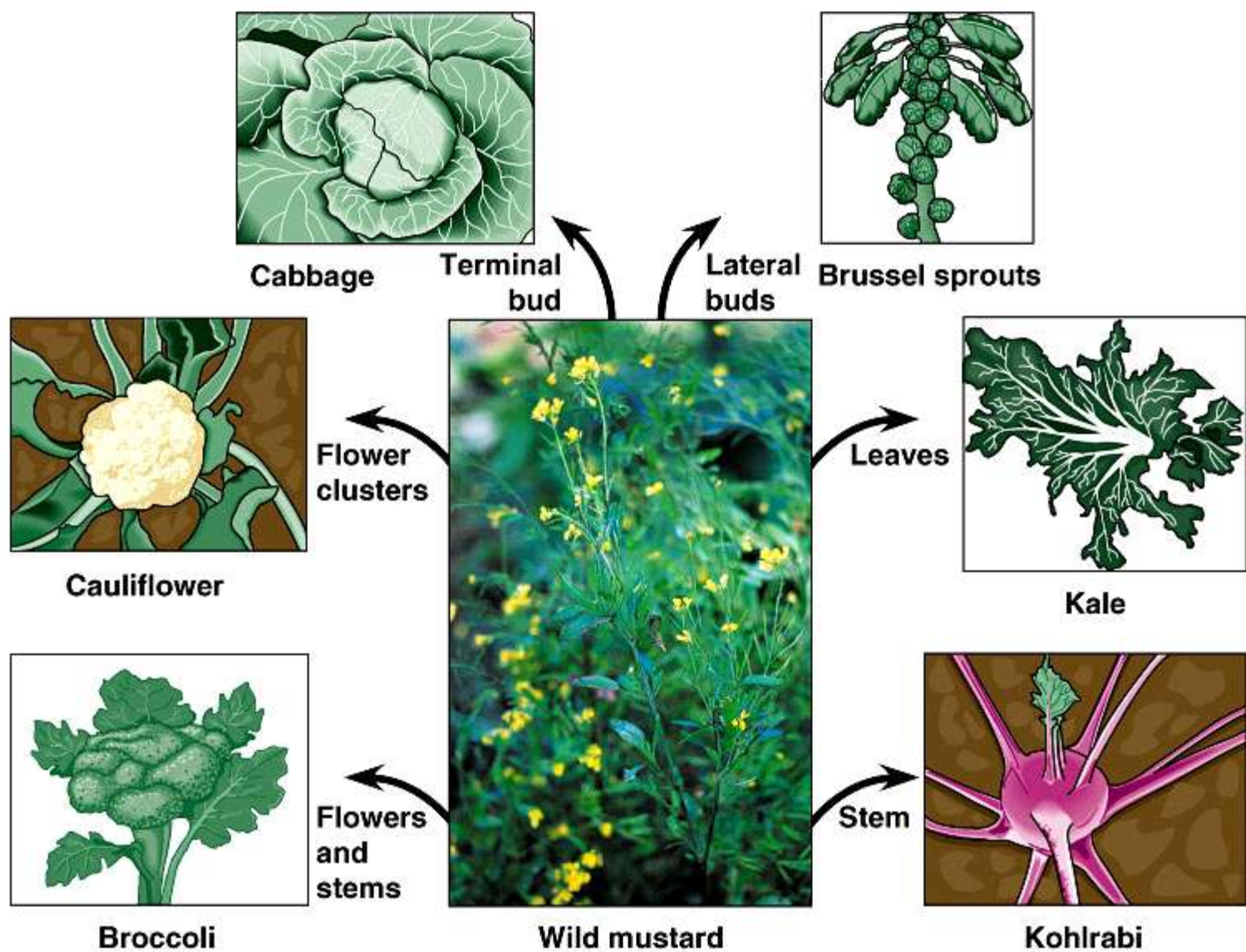
Artificial Selection



~10,000 years of evolution by artificial selection

LBR 10/2002

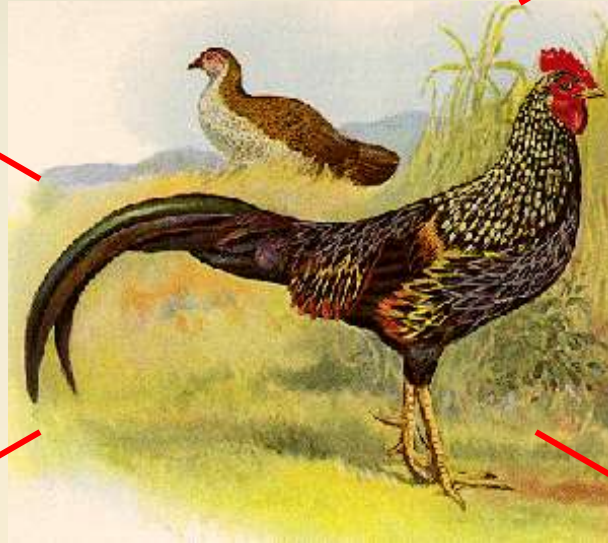
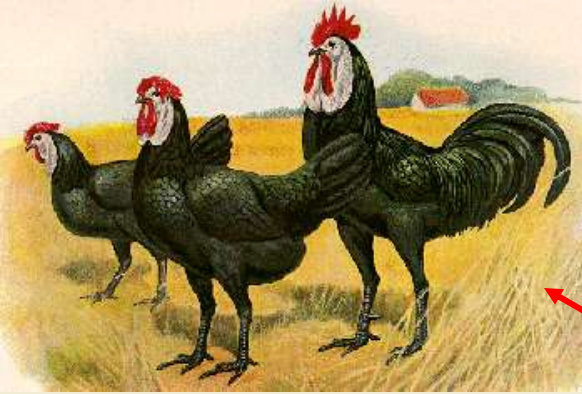
Artificial Selection





Corn has been developed from the ancestral wild grass, teosinte.

ARTIFICIAL SELECTION IN DOMESTIC ANIMALS



■ Grey Jungle fowl

Natural Selection

Some individuals in a population, because of their phenotypic characteristics, produce more offspring that themselves live to reproduce.

- Natural selection can favor, disfavor, or conserve the genetic make-up of a population.

The environmental factors leading to selection may be either.....



...biotic

...or abiotic.



Agents of Natural Selection

Abiotic factors

- Climate
- Geology
- Other non-living factors

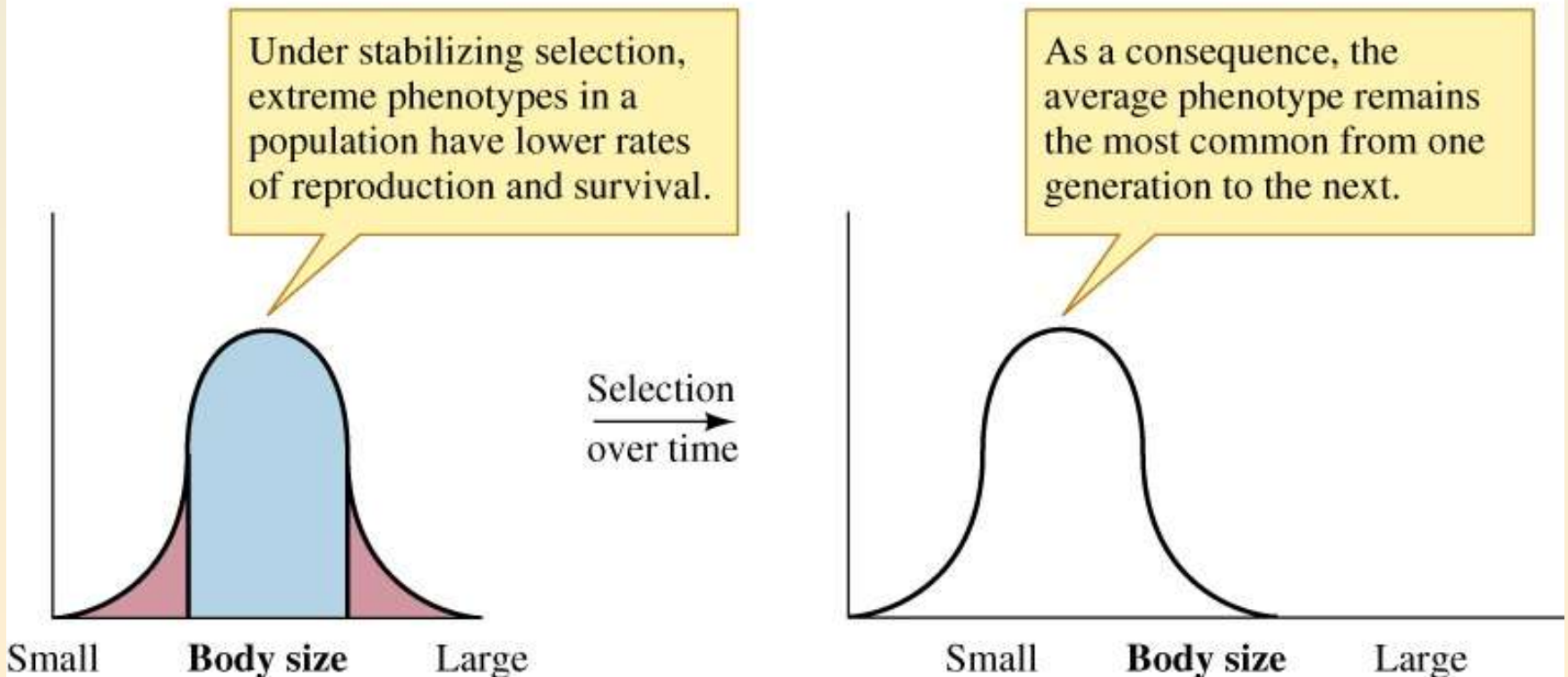
Biotic factors

- Competition
 - Food, Shelter, Mating
- Interspecies Interactions
 - Predation
- Sexual Selection

Stabilizing Selection

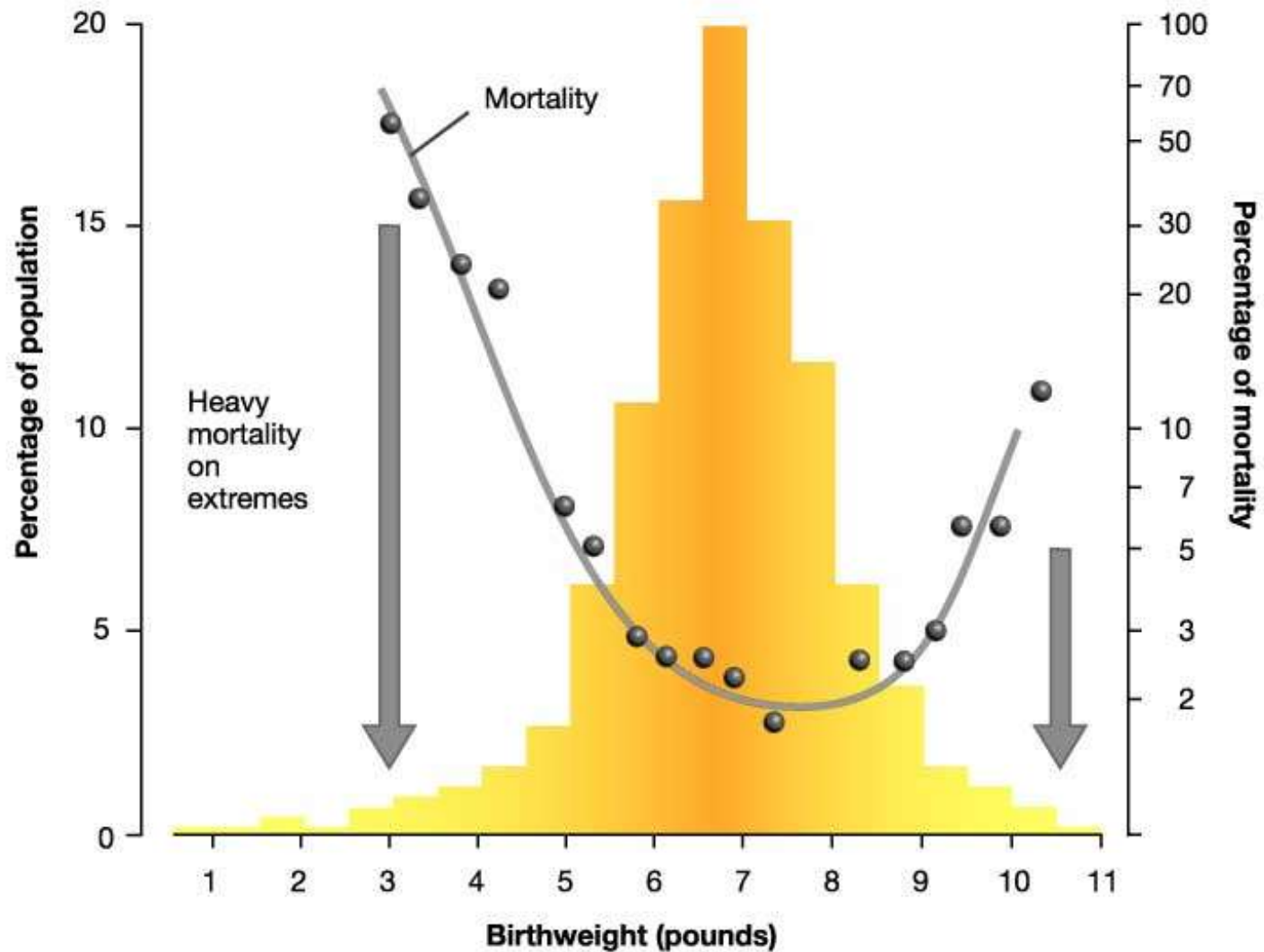
Stabilizing selection acts to impede changes in a population by acting against extreme phenotypes and favoring average phenotypes.

(a) Stabilizing selection



Stabilizing selection

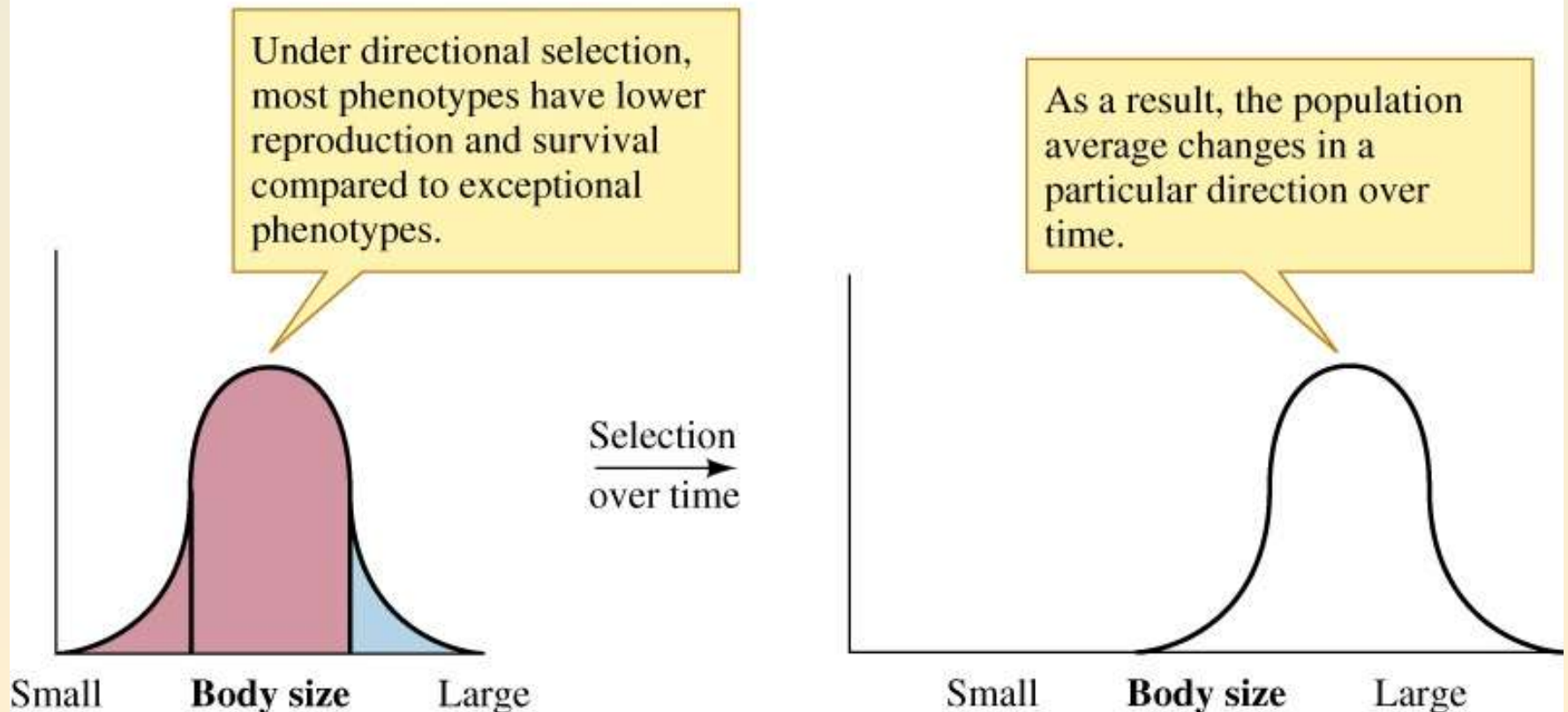
For example, very small and very large babies are most likely to die, leaving a narrower distribution of birthweights.



Directional Selection

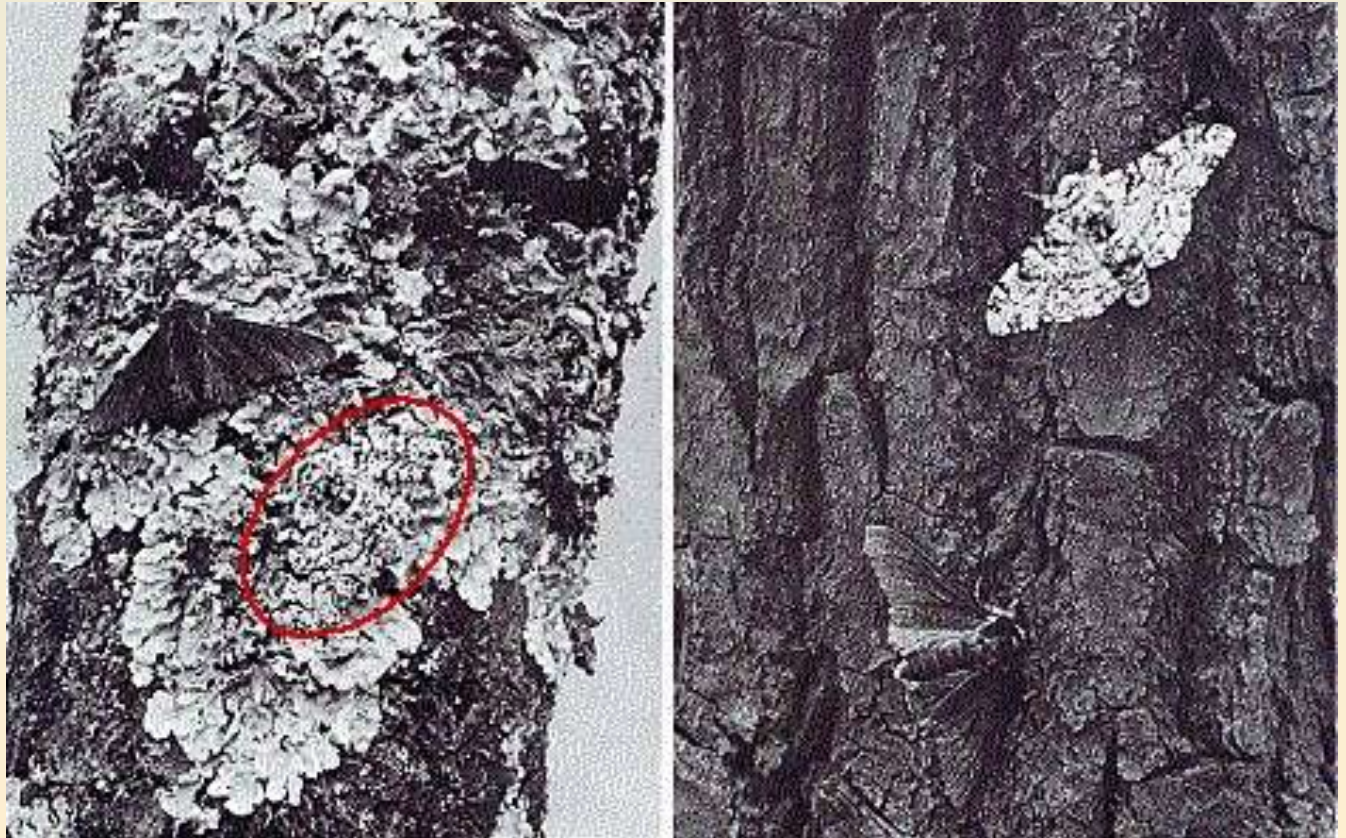
Directional selection leads to changes in phenotypes by favoring an extreme phenotype over other phenotypes in the population.

(b) Directional selection



Peppered moth – *Biston betularia*

The moth occurs in two color phases, peppered and melanic. (a) Both phases are displayed against an unpolluted, lichen-covered tree. (b) Both phases are displayed against a dark tree, on which the lichen were killed by pollution.



Peppered Moth *Biston betularia*

In unpolluted areas, trees are covered in lichens and the light form of the moth is hard to see

In mid 1800's, air pollution in British cities covered trees with coal dust and soot

In Victorian era cities, the dark form became common and the light form rare



Peppered Moth *Biston betularia*



- In the year 1848, 5% of the population was dark colored moths while 95% was light colored
- In the year 1895, 98% was dark colored while 2% was light colored
- In the year 1995, 19% was dark colored while 81% was light colored

Natural Selection for Pesticide Resistance

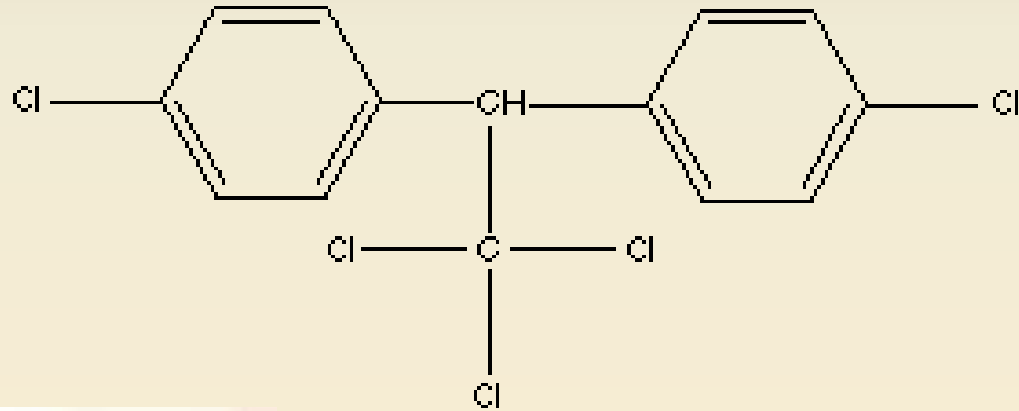


<http://www.museums.org.za/bio/insects/cockroaches/>

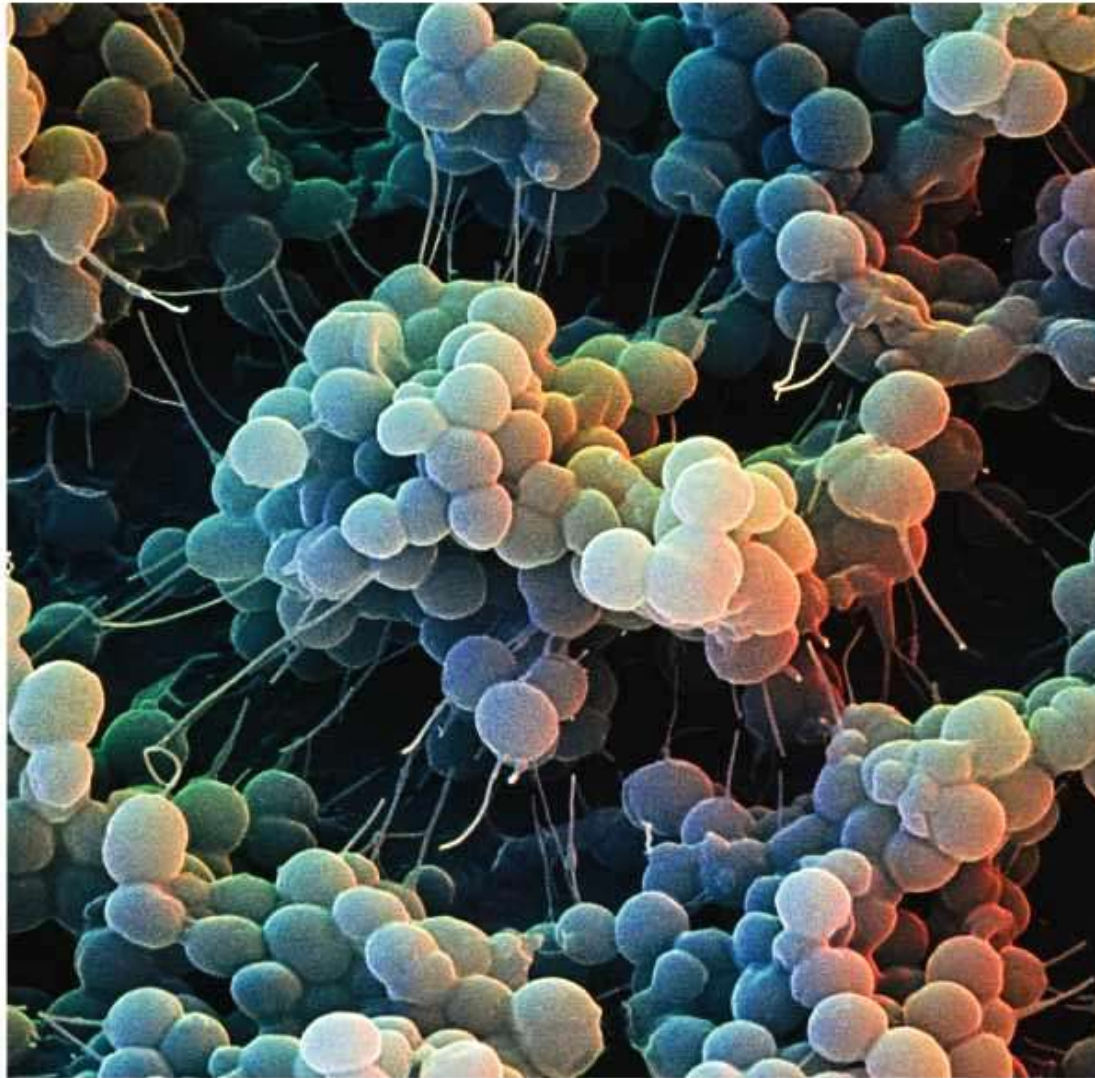
<http://home-supplies.best-emporium.com/cat-125/Cleaning-Sanitation/Cleaning-Chemicals/Rodenticide-Insecticides>

We can look at the evolution of resistance to insecticides as an example of natural selection

DDT is very effective in its first use. Over time, however, DDT-resistant mosquitoes begin to appear



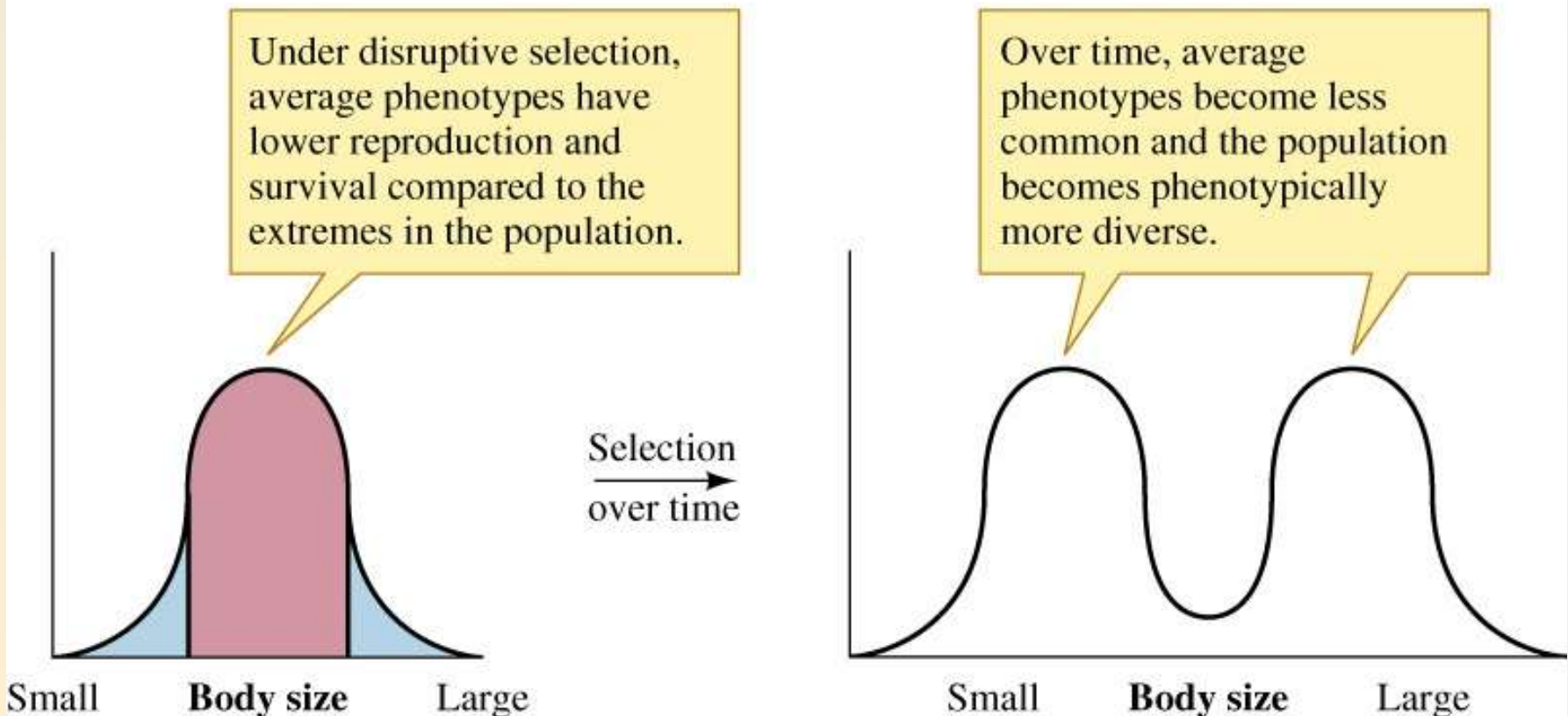
Staphylococcus aureus: antibiotic resistance



Disruptive Selection

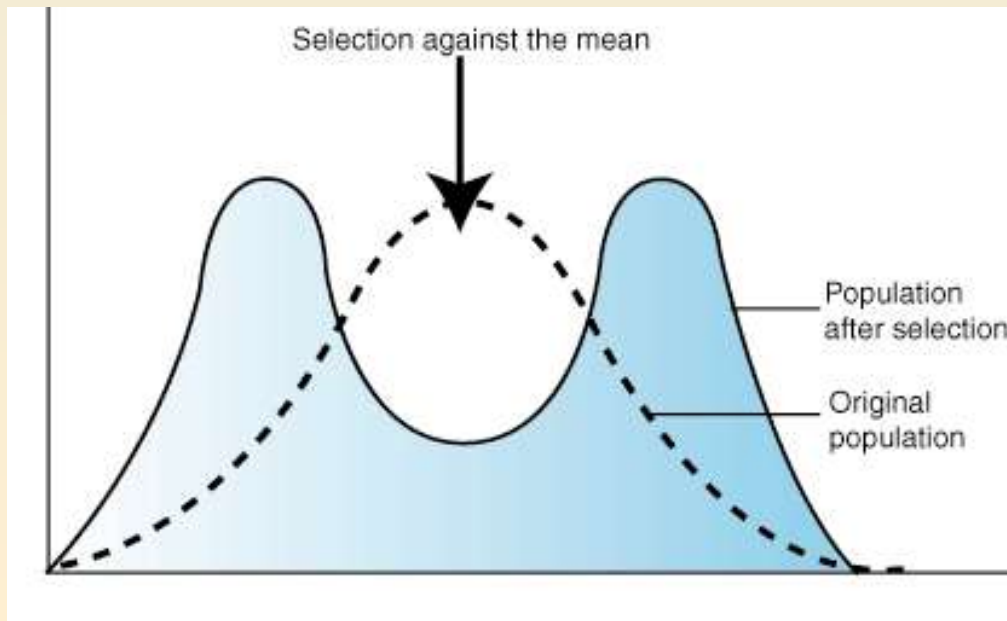
Disruptive selection creates bimodal distributions by favoring two or more extreme phenotypes over the average phenotype in a population.

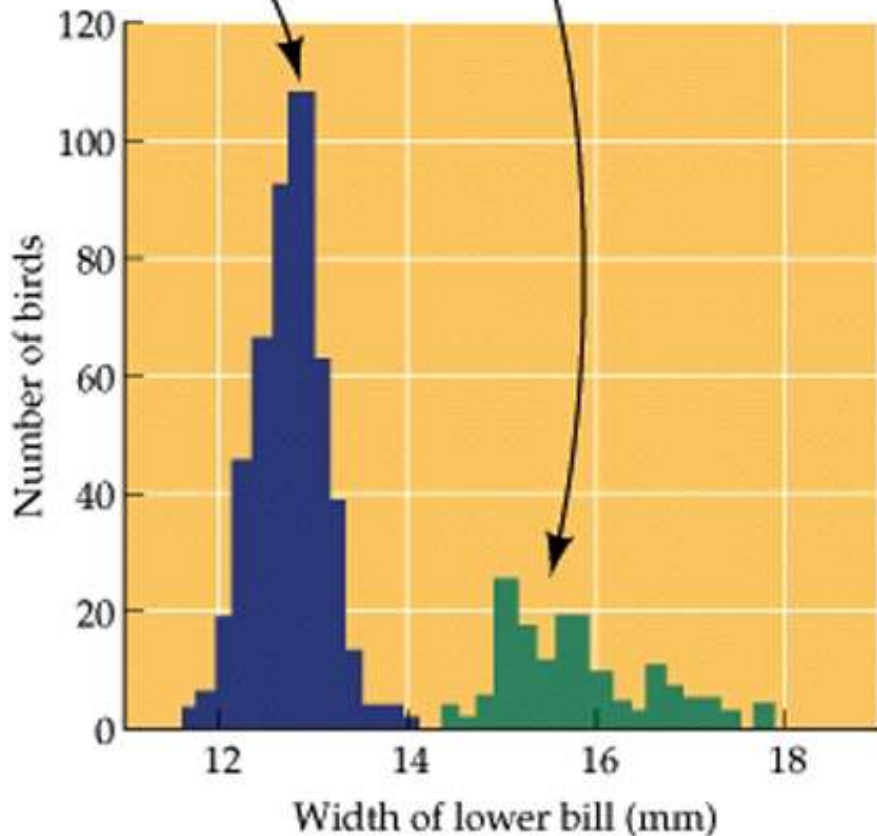
(c) Disruptive selection



Disruptive (diversifying)

occurs when extreme individuals are more fit





© 2001 Sinauer Associates, Inc.

These African finches depend on the seeds of two different types of sedge, one that produces a soft seed and the other a much harder seed.

Finches with small bills are efficient at feeding on soft seeds. Birds with larger bills are able to crack the hard seeds.

A study of 2700 finches produced the findings which appears to be observable evidence for disruptive selection.



rock pocket mouse

one phenotype is favored on the lava flows and the other is favored on the sandstone rocks

End