Variation within a Population: Population Genetics and Natural Selection

Chapter 4

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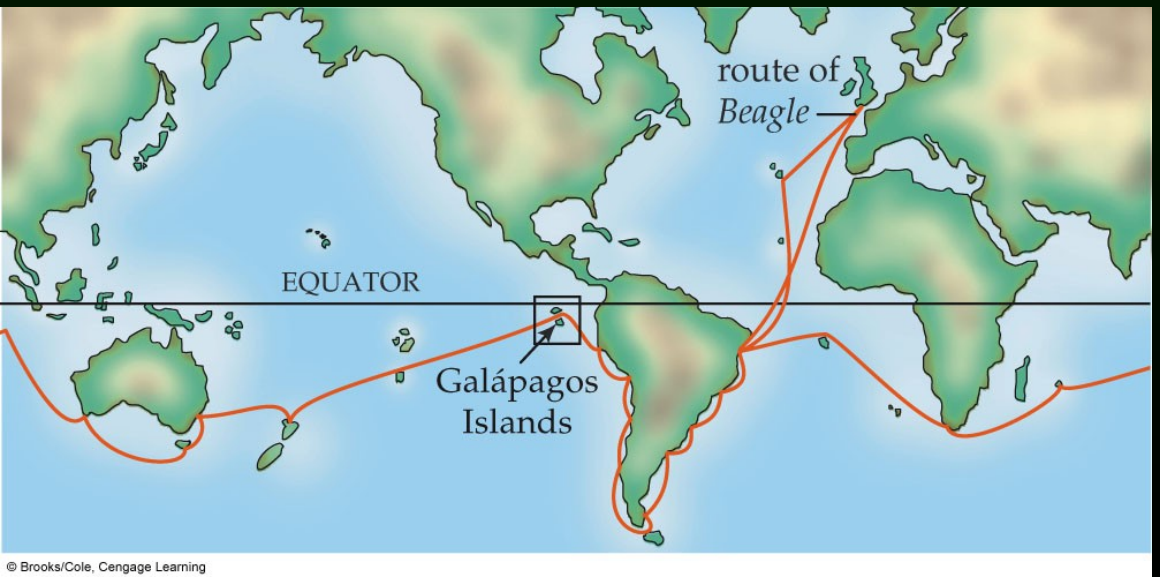
Darwin

1835 Charles Darwin visited the Galapagos Islands and became convinced various populations evolved

1838 After reading an essay by Thomas Malthus, he theorized some individuals would have a competitive advantage conferred by favorable characteristics.



Darwin's Theory of Natural Selection

- Chance variation between individuals.
  - Some are heritable.
- More offspring are produced each generation than can survive.
- Some individuals, because of physical or behavioral traits, have a higher chance of surviving AND REPRODUCING – an adaptive trait leading to adaptation within the population

Our society is getting taller. Why is this so? Ideas?

http://www.timesonline.co.uk/tol/news/uk/article532535.ece

The Father of Genetics: Gregor Mendel

- Augustinian Monk
  - Studied garden pea (*Pisum sativum*).
  - characteristics pass from parent to offspring genes.
    - Exist in alternate forms - alleles.
    - Some prevent expression of others (dominant & recessive)

Beyond Mendel - Genes and the Environment

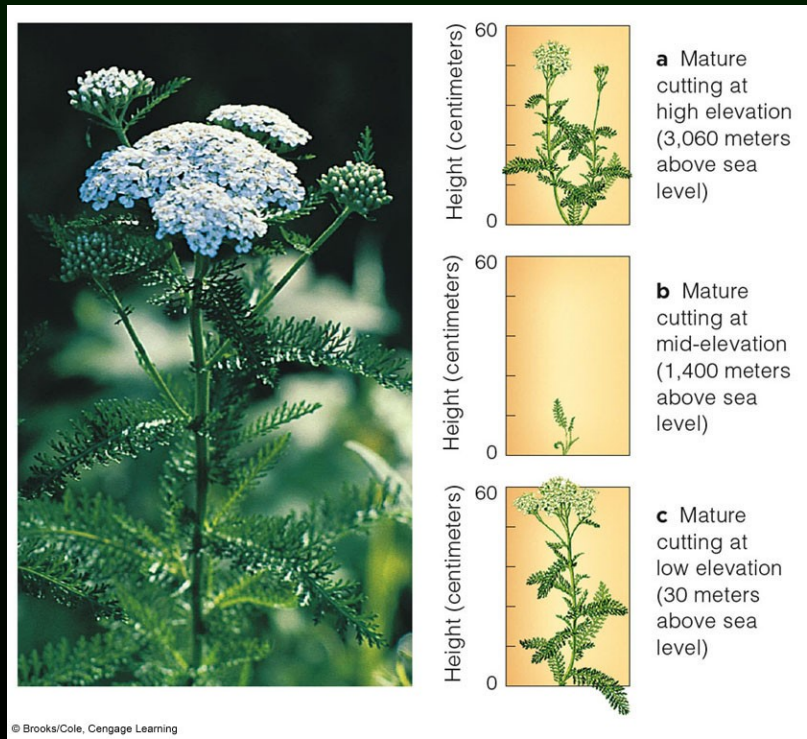
- Expression of some genes is affected by environmental factors such as temperature, altitude, or chemical exposure

- The result may be variation in traits

Beyond Mendel - Genes and the Environment

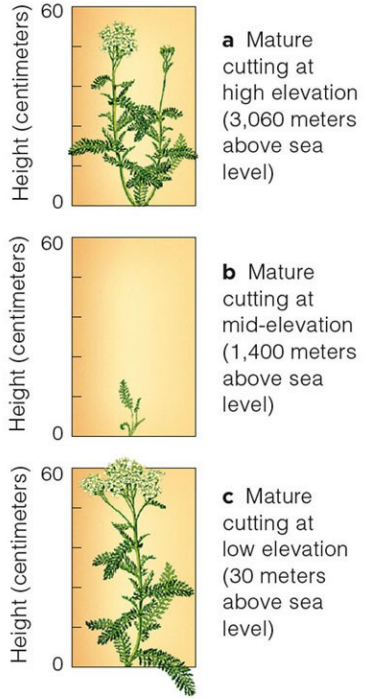
- Enzyme tyrosinase, works at low temperatures

Guys at Stanford did this one!



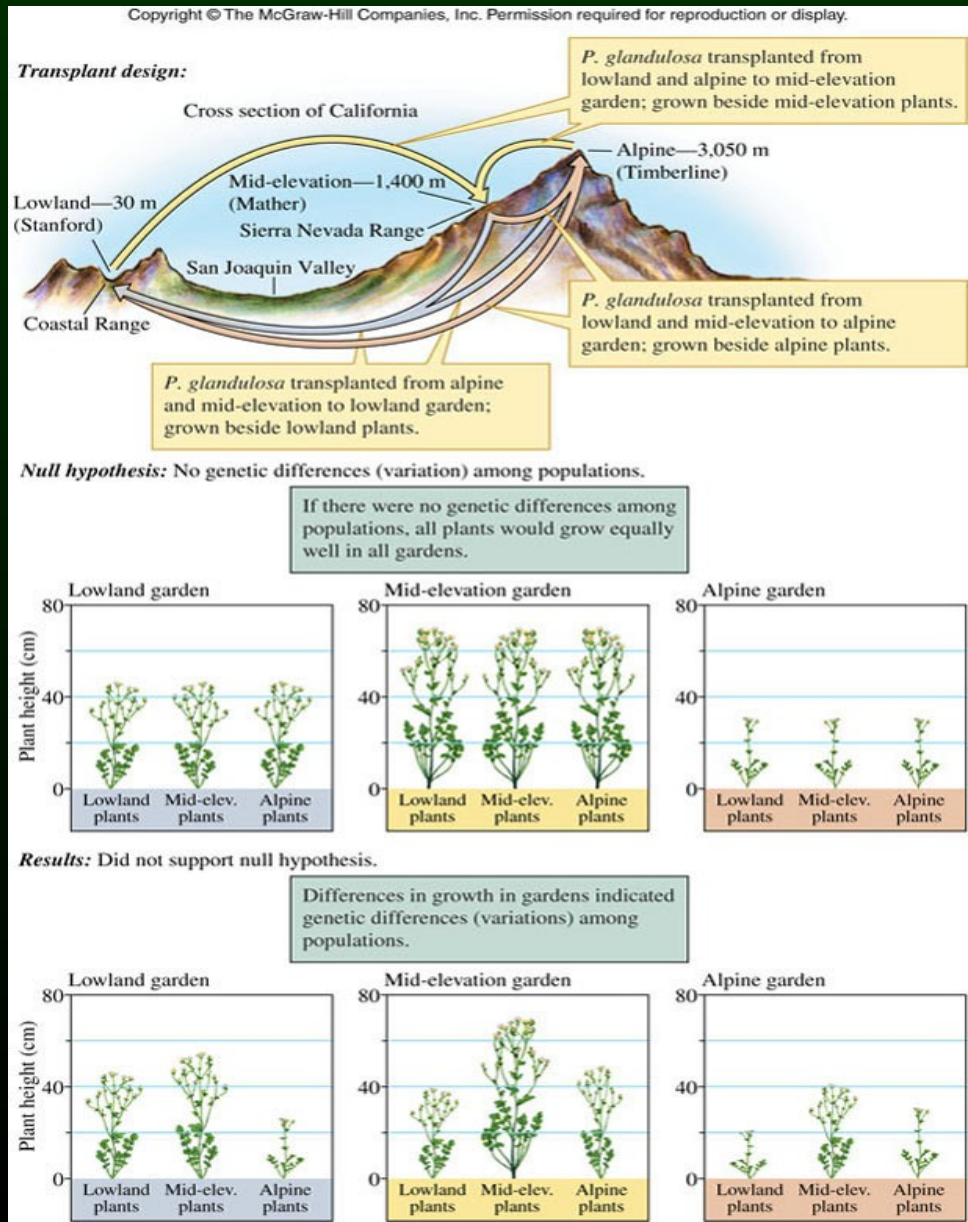
Variation Within Populations

- Variation in Plant Populations
  - Phenotypic differences (growth and flower production) within **clones** grown at the 3 elevations are the result of environmental differences
    - **Phenotypic plasticity**



Variation Within Populations – Can be genetic as well!!!

- Variation in Plant Populations
  - Many plant species differ dramatically in form from one elevation to another.
    - Distinctive **ecotypes** (locally adapted – different genetics)



Population Genetics

Hardy Weinberg – the fathers of population genetics

- Hardy Weinberg principle states that in a population mating at random in the absence of evolutionary forces, allele frequencies will remain constant. NO EVOLUTION!!!

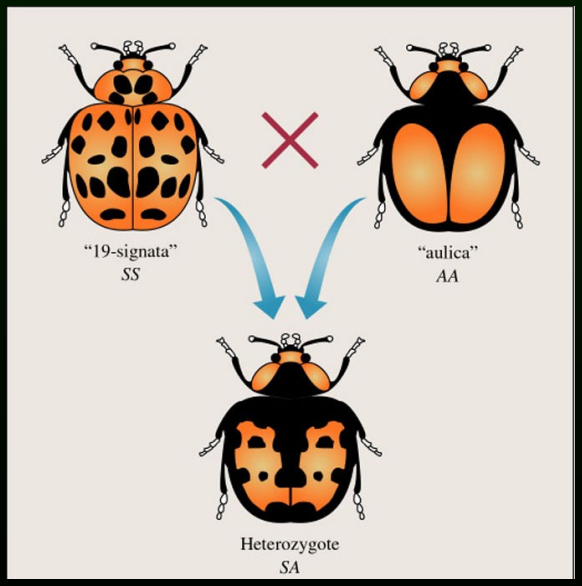
$$p^2+2pq+q^2 = 1.0$$

p= frequency of allele 1 (dominant)
q = frequency of allele 2 (recessive)

p^2 = frequency of PP (AA) genotype in a population
2pq = frequency of Pq (Aa) genotype in a population
q^2 = frequency of qq (aa) genotype in a population

Calculating Gene Frequencies

- SS (81%) SA (18%) AA (1%)
  - Frequency of S allele ?
    - SS + 1/2SA = .81 + ½(.18) = .90
      - $(.90)^2 + 2(.9x.1) + (.10)^2 = 1.0$



Conditions Necessary for Hardy Weinberg

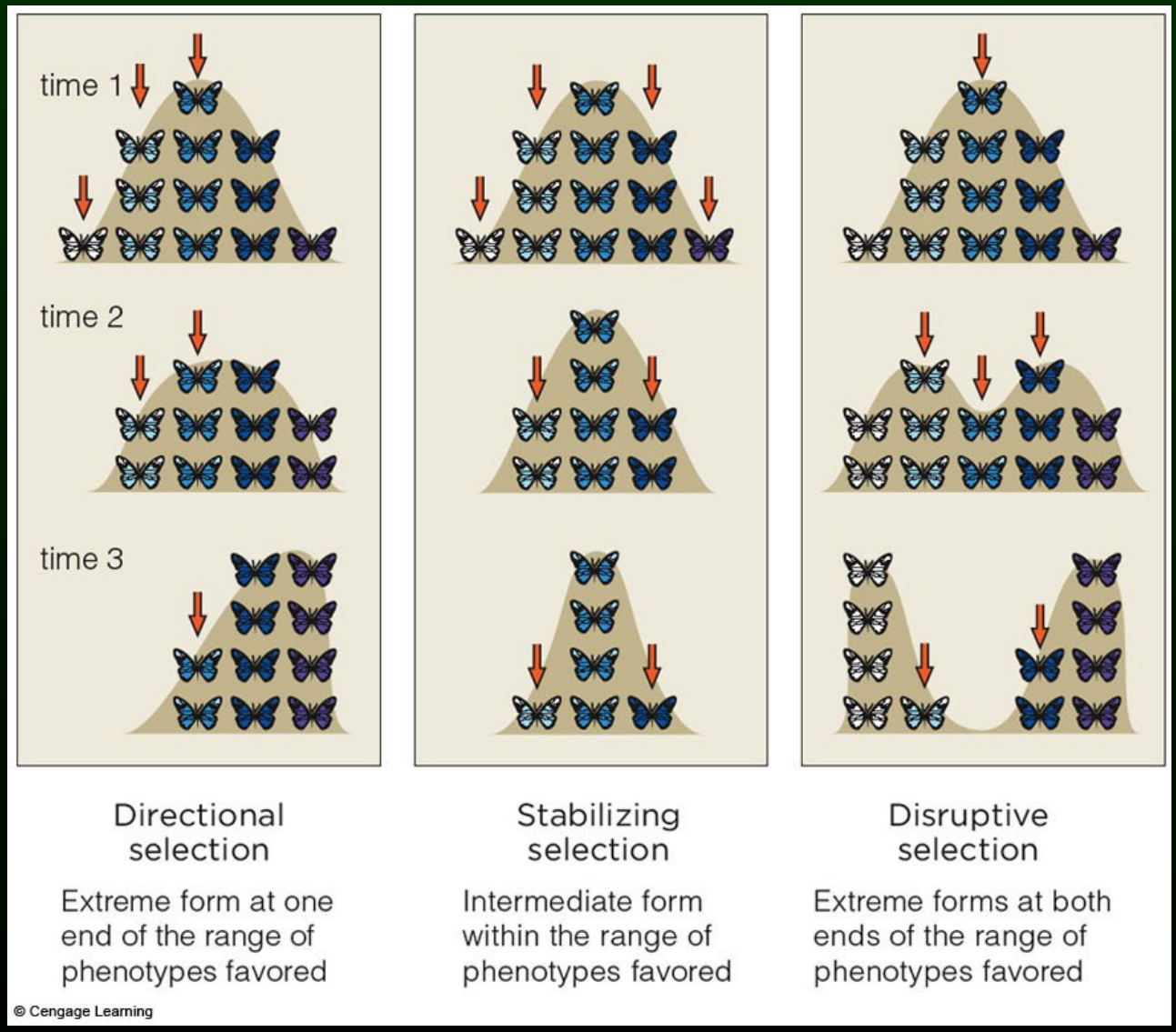
- Random Mating
- No Mutations
- Large Population Size (no genetic drift)
- No Immigration
- Equitable Fitness Between All Genotypes
  - Likely, at least one of these will not be met and allele frequencies will change.
    - Potential for evolutionary change in natural populations is very great.

Natural Selection

- Natural selection
  - Differential survival and reproduction among individuals of a population that show variations in details of their shared traits (alleles)

- Allele frequencies
  - Maintained by stabilizing selection
  - Shifted by directional or disruptive selection

Modes of Natural Selection



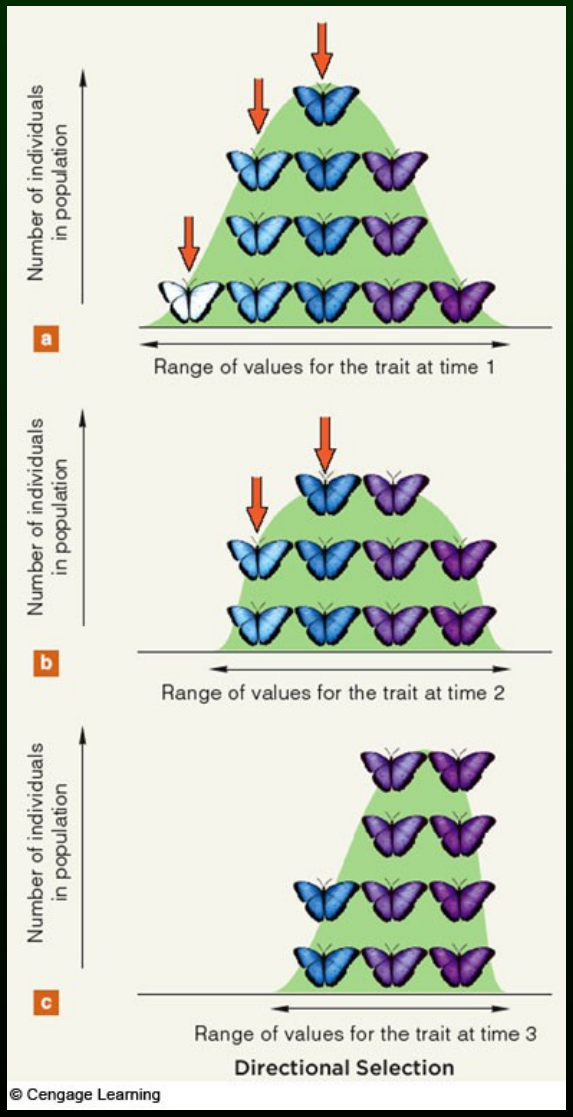
Directional Selection

- Shifts range of variation in traits in one direction
  - Individuals at one end of the range are favored; those at the other end are not

- *Examples:*
  - Peppered moth
  - Antibiotic resistance

http://www.youtube.com/watch?v=LyRA207dJLc

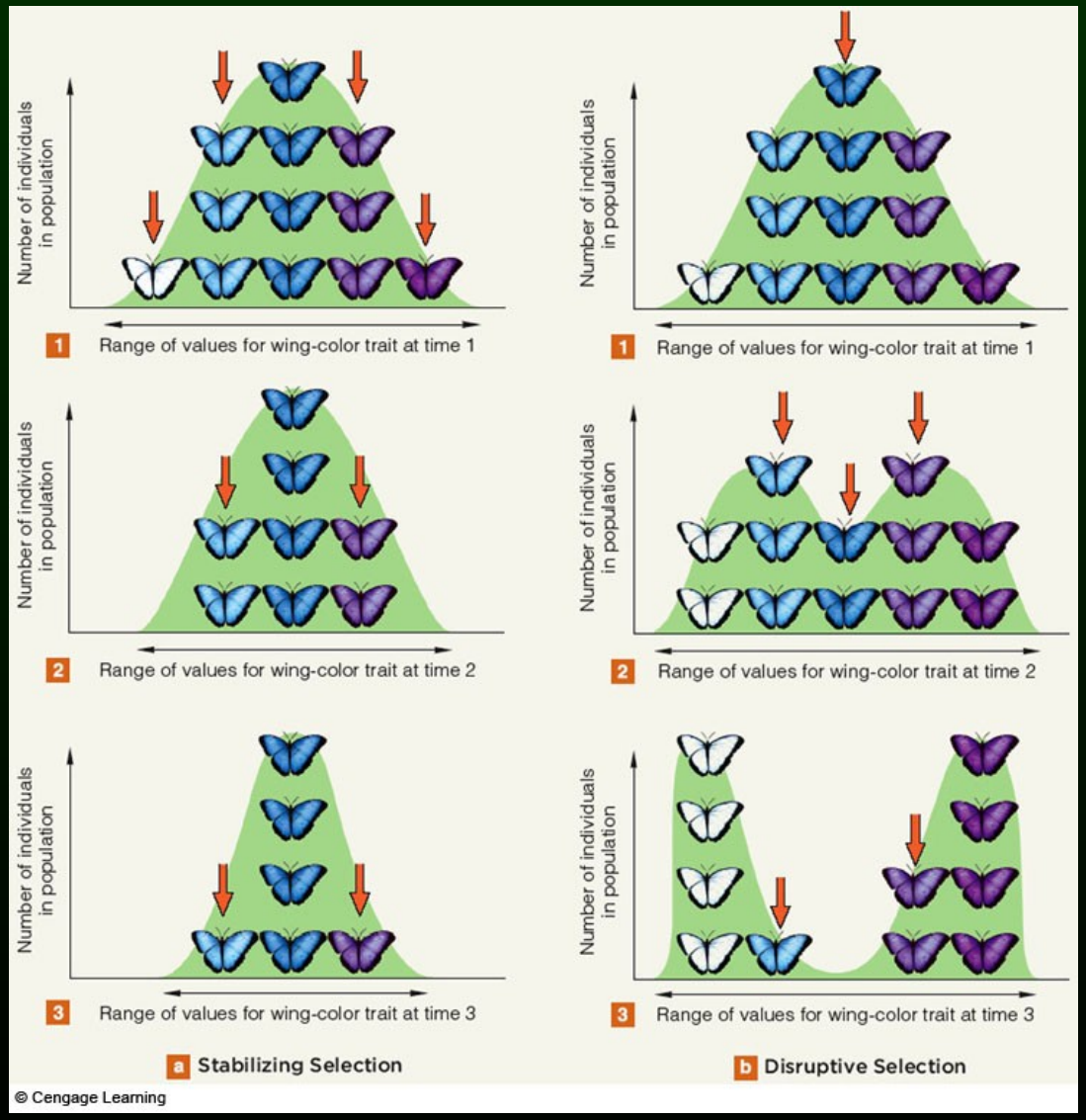
Directional Selection



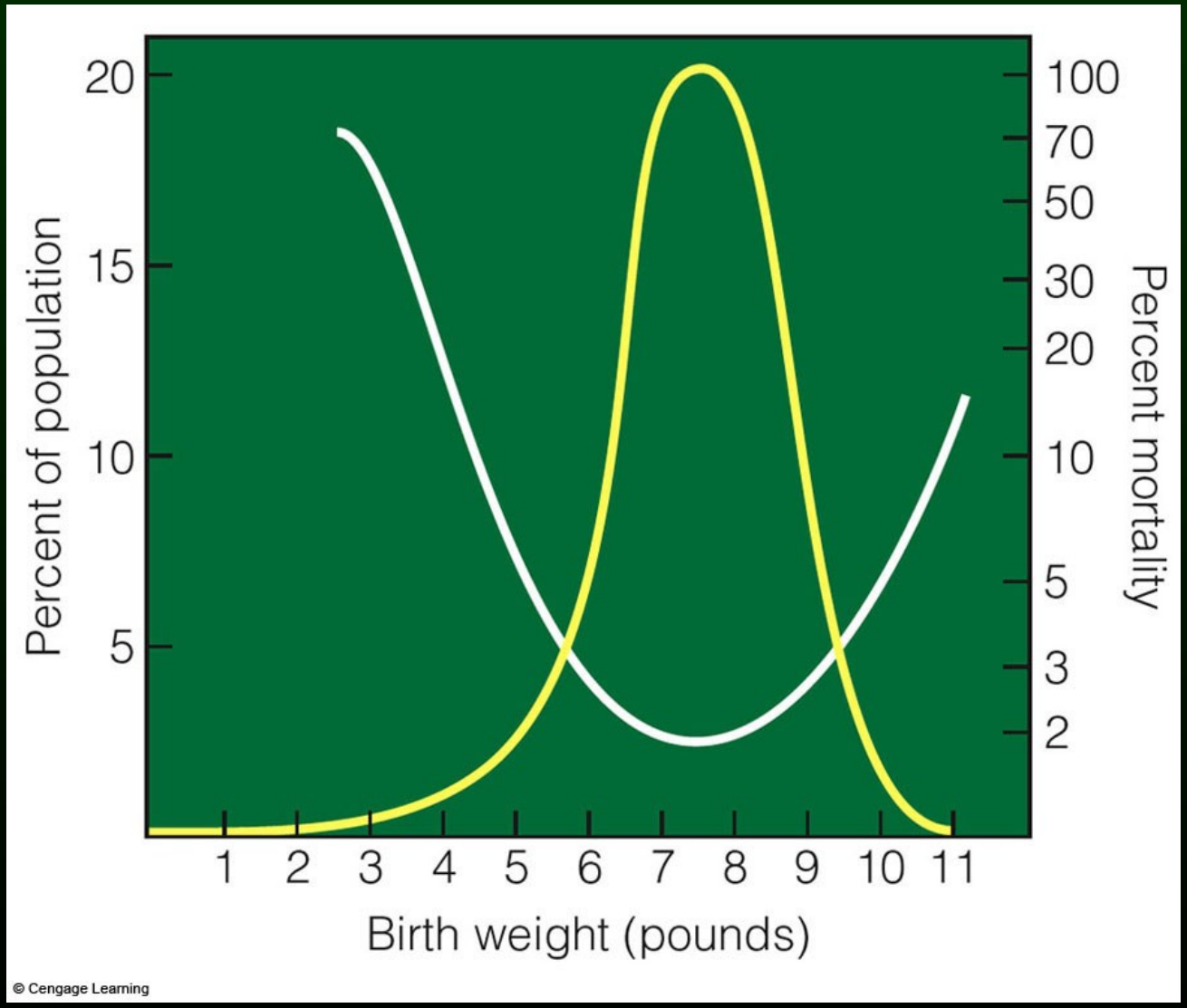
Selection For or Against Extreme Phenotypes

- Stabilizing Selection
  - Works against both extremes in the range of phenotypic variation
  - Favors intermediate forms
- Disruptive selection
  - Favors forms at extremes of the range

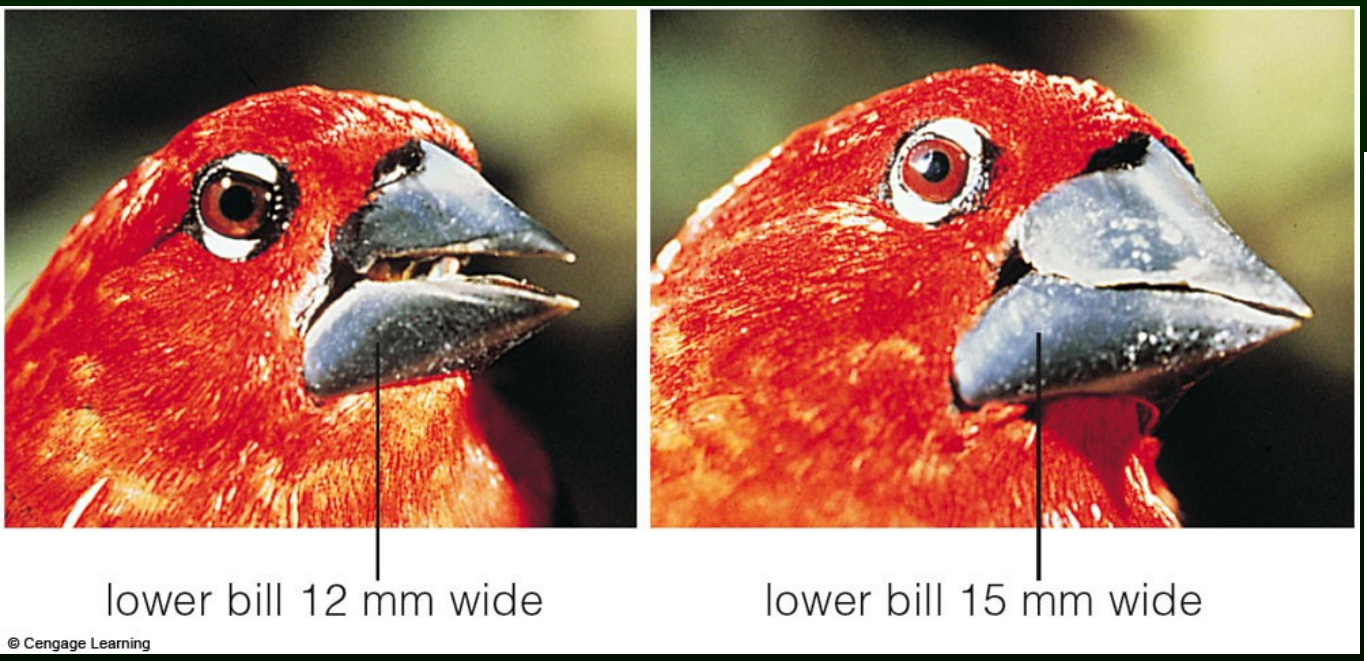
Stabilizing and Disruptive Selection

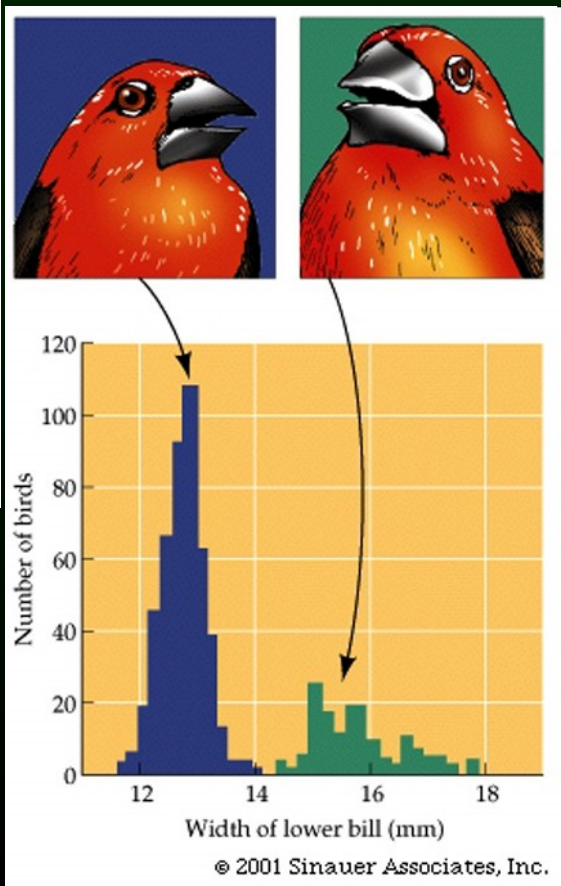


Stabilizing Selection: Birth Weight



Disruptive Selection: Finch Bill Size





Genetic Drift – Change due to chance!

- Genetic drift
  - Random change in a population's allele frequencies over time, due to chance
  - It's not always natural selection!!!
  - Can lead to loss of genetic diversity

http://www.youtube.com/watch?v=zPcSxOX1I_0

- Most pronounced in small or inbred populations
  - Bottleneck: Drastic reduction in population
  - Founder effect: Small founding group