Variation within a Population: Population Genetics and Natural Selection

Chapter 4

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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)
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?
  - \( SS + \frac{1}{2}SA = 0.81 + \frac{1}{2}(0.18) = 0.90 \)
  - \( (0.90)^2 + 2(0.9 \times 0.1) + (0.10)^2 = 1.0 \)
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
Extreme form at one end of the range of phenotypes favored

Stabilizing selection
Intermediate form within the range of phenotypes favored

Disruptive selection
Extreme forms at both ends of the range of phenotypes favored
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=LyRA807djLc
Directional Selection

Diagram showing changes in the distribution of a trait over time due to 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

lower bill 12 mm wide
lower bill 15 mm wide

Number of birds

Width of lower bill (mm)
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