**Chapter 7  
Beyond alleles: quantitative genetics and the evolution of phenotypes**

Continuous traits have a complex genetic basis

* **Polygenic trait:** influenced by many genetic loci
  + Interaction between alleles (epistasis)
  + Interaction with environment (phenotypic plasticity)
* **Quantitative genetics:** study of the genetic mechanisms of continuous phenotypic traits

**Epistasis**

* **Epistasis** is a phenomenon in which the expression of one gene depends on the presence of one or more "'modifier genes'." A gene whose phenotype is expressed is called epistatic, while one whose phenotype is altered or suppressed is called hypostatic.
* Ex: Labrador retrievers

**Phenotypic plasticity**

* **Phenotypic plasticity** is the ability of an organism to change its phenotype in response to changes in the environment.
* Phenotypic plasticity encompasses all types of environmentally induced changes (e.g. morphological, physiological, behavioral) that may or may not be permanent throughout an individual’s lifespan.
* It is NOT evolution.
* Ex: *Daphnia*

When components of variation are additive, genetic and environmental variance sum to total phenotypic variance

* Heritability is the proportion of phenotypic variance due to genetic differences
* Broad sense heritability includes:
  + Additive effects
  + Dominance effects
  + Epistatic effects
  + Maternal/Paternal environmental effects

**Natural Selection**

The process in nature by which, according to Darwin's theory of evolution, only the organisms best adapted to their environment tend to survive and transmit their genetic characteristics in increasing numbers to succeeding generations while those less adapted tend to be eliminated.

* Natural selection is a mechanism that causes evolution. It occurs when some kinds of organisms in a population leave more offspring than other kinds of organisms; the result is that the kinds of organisms who leave more offspring will increase in frequency over time.
* Natural selection can be understood as a logical argument in which a conclusion follows from a set of premises (or a result follows from a set of initial conditions). Natural selection will operate on anything that has the following properties:
  + Reproduction
    - New generation must exist
  + inheritance
    - “like must reproduce like”
  + variation in fitness
    - Some individuals are more likely to reproduce
    - The fitness of an organism, in its simplest evolutionary sense, is how many successful offspring an individual has
  + variation in individual characteristic
    - There must be variation in phenotype (ergo genotype)

**Modes of selection**

* Directional Selection
  + Directional selection favors those individuals who have extreme variations in traits within a population.
  + A useful example can be found in the breeding of the greyhound dog. Early breeders were interested in dog with the greatest speed. They carefully selected from a group of hounds those who ran the fastest.
  + From their offspring, the greyhound breeders again selected those dogs who ran the fastest. By continuing this selection for those dogs who ran faster than most of the hound dog population, they gradually produced a dog who could run up to 64km/h (40mph).
  + The greyhound was originally used to hunt the fastest of game, fox and deer. Their breed dates to Egypt in 3BCE.
* Stabilizing selection
  + Stabilizing selection favors the norm, the common, average traits in a population.
  + Look at the Siberian Husky, a dog bred for working in the snow.
  + The Siberian Husky is a medium dog, males weighing 16-27kg (35-60lbs). These dogs have strong pectoral and leg muscles, allowing it to move through dense snow.
  + If the Siberian Husky had heavier muscles, it would sink deeper into the snow, so they would move slower or would sink and get stuck in the snow.
  + Yet if the Siberian Husky had lighter muscles, it would not be strong enough to pull sleds and equipment, so the dog would have little value as a working dog.
  + So stabilizing selection has chosen a norm for the size of the Siberian Husky.
* Disruptive selection
  + Disruptive (diversifying) selection, like directional selection, favors the extremes traits in a population. Disruptive selection differs in that sudden changes in the environment creates a sudden force favoring that extreme.
  + Think about the changes in the environment when that meteor crashed into Earth 65mya. A sudden decrease in light levels as the dust rose over large portions of the Earth. Extremely large tidal waves washing miles over the land. Increased seismic activity.
  + The sudden lost of food along the coast, possible plague due to the high initial death rate, dust filling the lungs of animals would have been the most stressful on larger animals.
  + Large animals need a large oxygen supply to supply energy to their muscles. They also need a large, constant supply of food.
  + The sudden drop of oxygen due to the dust, and the drop in fresh food, large animals would be stressed. If a plague started by the high death rate also hit these stressed animals, they would have been sorely pushed to survive. Evidence shows that they did not. So disruptive selection occurs quickly, selecting for those extreme traits that help organisms survive in the new environmental conditions.
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**Evolutionary response to selection**

* How much the population changes depends on:
  + Selection differential (*S*)
  + Heritability

**Selection coefficient**

* The **selection coefficient** is a measure of the relative fitness of a phenotype. Usually denoted by the letter *s*, it compares the fitness of a phenotype to another favored phenotype, and is the proportional amount that the considered phenotype is *less* fit as measured by fertile progeny.
* *s* = 0 then is selectively neutral compared to the favored phenotype, while *s* = 1 indicates complete lethality.

SO…

* Evolution and selection are not the same
  + Selection can occur without evolution
* The magnitude of change depends on:
  + Strength of selection (selection differential)
  + Heritability

**Quantitative trait loci** (QTLs)

* **Quantitative trait loci** (QTLs) are stretches of DNA containing or linked to the genes that underlie a quantitative trait. Mapping regions of the genome that contain genes involved in specifying a quantitative trait is done using molecular tags, commonly SNPs.
* **Quantitative traits** refer to phenotypes (characteristics) that vary in degree and can be attributed to polygenic effects, i.e., product of two or more genes, and their environment.
* E.g. *Agouti*