**Chapter 5**

**Are You Only as Smart as Your Genes?  
Mendelian and Quantitative Genetics**

**The Inheritance of Traits**

* Offspring resemble their parents, but not exactly.
* Siblings resemble each other, but not exactly.
* How much is because of environment?
* How much is inherited?
* The human life cycle:
  + Adults produce **gametes** in their **gonads** by **meiosis**.
  + Sperm cells fertilize egg cells to form single-celled **zygotes**.
  + Repeated cell divisions form the **embryo**.
* The human life cycle, cont.:
  + The embryo grow to become a **fetus**.
  + After birth, the individual continues to grow until reaching adulthood.
* **Genes** are segments of DNA that code for proteins.
  + Analogous to words in an instruction manual for building a human
* **Chromosomes** are analogous to pages in the instruction manual.
  + Each “page” contains thousands of “words”
  + Different types of cells use different words, in different orders

**Producing Diversity in Offspring**

* Mistakes in copying DNA (**mutations**) produce different versions of genes (**alleles**), with different results.
* Parent cell has two complete copies of the manual:   
  23-page copy from mom and 23-page copy from dad
  + 23 pairs of homologous chromosomes
* **Random fertilization** produces more diversity:   
  64 trillion possibilities!
* No two humans are genetically identical, except for **monozygotic twins**.
  + **Dizygotic twins** are 50% identical just like siblings born at different times.

**Mendelian Genetics: When the Role of Genes Is Clear**

* **Gregor Mendel:** first to accurately describe rules of inheritance for simple traits
* His research involved controlled mating between pea plants.
* His pattern of inheritance occurs primarily in traits that are due to a single gene with a few alleles.
* Mendel’s principles also apply to many genetic diseases in humans.
* **Phenotype**: physical traits of an individual
* **Genotype**: description of the alleles for a particular gene in an individual
  + **Homozygous** (**-ote**): both alleles for a gene are identical
  + **Heterozygous** (**-ote**): the gene has two different alleles
* **Recessive**: the phenotype of an allele is seen only when homozygous
* **Dominant**: the phenotype is seen when homozygous or heterozygous

**Genetic Diseases in Humans**

* **Cystic fibrosis**: a **recessive** human genetic disease
  + Defect in chloride ion transport
  + Causes recurrent lung infections, dramatically shortened lifespans
  + Heterozygotes (**carriers**) do not show the symptoms
  + Most common recessive disease among Europeans
* **Huntington’s disease:** a dominant human genetic disease
  + Progressive, incurable, always fatal
  + Symptoms occur in middle age
  + Mutant protein forms clumps inside nerve cell nuclei, killing the cells
  + Having a normal allele cannot compensate for this

**Using Punnett Squares to Predict Offspring Genotypes**

* Punnett square: graphic way to predict possible outcomes of a **cross**
* Consider a cross between two cystic fibrosis carriers
* “*F*” = normal allele; “*f*” = recessive disease allele
* The cross would be: *F f* x *F f*
* What offspring could result?
* Dihybrid crosses are crosses that involve two traits.
* The first step in a dihybrid is to determine the possible gametes.
* Yellow (*Y*) is dominant to green (*y*) and Round (*R*) is dominant to wrinkled (*r*).
* If you cross *YyRr* x *YyRr*,
  + Possible gametes for parent 1 are *YR*, *Yr*, *yR*, *yr*
  + Possible gametes for parent 2 are *YR*, *Yr*, *yR*, *yr*
* The results of the cross results in a 9:3:3:1 phenotypic ratio.

**Quantitative Genetics: When Genes and Environment Interact**

* Quantitative traits show continuous variation:
  + Large range of phenotypes
  + E.g., height, weight, intelligence
* Variation due to both genetic and environmental differences
* **Mean**: sum up all the phenotypic values and divide by the number of individuals; same as the average.
* **Variance**: a measure of how much variability there is in the population

**Quantitative Genetics - Why Traits Are Quantitative**

* Quantitative traits, with continuous variation, are **polygenic traits**.
  + Result of several genes
  + Each with more than one allele
* Interaction of multiple genes with multiple alleles results in many phenotypes.
* Example: human eye color
* **Heritability**: proportion of the variation within a population due to genetic differences among individuals
* Have to use correlation to measure heritability in humans
* Scientists seek **“natural experiments,”** situations in which either the overlap in genes or environment is removed
* Twins are often used
  + Monozygotic twins share all their genes and their environment
  + Dizygotic twins share environment, but only half their genes
  + Heritability of IQ from such twin studies estimated to be about 0.52
* Twins share a more similar environment than most humans
  + Similar treatment of twins might explain why their IQs are so similar
  + Monozygotic twins raised apart share all genes but are treated like everyone else
  + Estimates of IQ heritability for such twins is 0.72
  + Drawback: limited number of such twins to study
  + Table 7.2 discusses IQ heritability

**Genes, Environment, and the Individual - The Use and Misuse of Heritability**

* Differences between groups may be environmental, despite a high heritability
  + A heritability value pertains just to the population in which it was measured, and to the environment of that population
* Imagine a laboratory population of mice of varying weights
  + Divide this population into 2 genetically identical groups
  + Give one group a rich diet, the other a poor diet
  + The “rich diet” mice will be bigger than the “poor diet” mice.
* Allow the mice in each group to breed, maintaining their diets.
* Measure the weight of adult offspring; correlation with parents shows   
  high heritability.
* Instead of body weight in mice, consider IQ in humans.
  + Affluent group: higher IQs
  + Impoverished group: lower IQs
* Conclude that the difference is probably due to genetics?
  + A highly heritable trait can still respond to environmental change.
  + Maze-learning ability is highly heritable in rats.
  + Bright rats have bright offspring
  + Dull rats have dull offspring
  + Still, no rats learned well in a restricted environment.
  + All rats learned better in an enriched environment.
* Heritability does not tell us about individual differences.
* Heritability is based on variances in populations.
* High heritability value for a trait does not automatically mean that most of the difference between two individuals is genetic.

**Genes, Environment, and the Individual - How Do Genes Matter?**

* Genes have a strong influence on even complex traits.
* But, independent assortment of multiple genes with multiple alleles produces a large number of phenotypes.
* Environment can also have big effects.
* For quantitative traits, it is difficult to predict the phenotype of children from the phenotypes of the parents.