How is genotype determined?

- How does DNA code for the making of proteins?
- How do the two copies of DNA you carry work together to create your phenotype?
- How do you get your two copies of any chromosome or locus through meiosis?
Meiosis

• How does meiosis divide cells?
• What are haploid and diploid cells?
• Describe the process of meiosis?
• When and how during meiosis is variation introduced?
• How do you get new genotypes?
Variation comes from

- Recombination
- Cross Over
- Mutation
Mutation

• Change in base sequence of DNA
• Occurs during replication stage of meiosis (or mitosis)
• MAY change the amino acid change and therefore the protein
Kinds of Mutations

- **Substitution** - replace one base with another
- **Frame Shift** -
  - **Insertion** - an extra base gets pulled in
  - **Deletion** - a base gets omitted
Do all mutations change the protein created?
Mutations?

- “Bad” - reduces the protein’s ability to function causing reduction in fitness
- Neutral - no change in protein form or function
- “Good” - increases protein’s ability to function, enhances fitness
Figure 3.15

“Bad” Mutations
Point mutation changes amino acid in active site of the protein
- Reduction in the protein’s ability to function, causing mild reduction in fitness
- If the protein is essential, could be a lethal mutation incompatible with life

“Neutral” Mutations
Point mutation that results in codon that codes for the original amino acid
- No change in protein structure or function

“Good” Mutations
Point mutation changes amino acid but outside the active site of the protein
- No change in protein function
Point mutation changes amino acid in active site of the protein
- Increase in the protein’s ability to function, causing mild increase in fitness
Mutation in regulatory gene that greatly increases production of an enzyme
- Enhances fitness and quickly spreads throughout the population
How common is mutation?

• happens all the time
• assume a rate of one in 100 million bases
• repair mechanisms fix 99% for effective mutation rate of $10^{-10}$
• gives a rate of 130 mutations per individual per generation
How is phenotype created?

- phenotype = genotype + environment
- genotype = combination of the two particles of inheritance we carry for each locus
- plus other involved loci
Most human traits...

• Polygenic
  • controlled by 2 or more loci
• Affected by the environment
• Many genes PLEIOTROPIC
  • a single gene has multiple effects
Example: Height

- **phenotype = genotype + environment**
- **environment = diet, altitude, sleep, health**
- **genotype = pairs of alleles at at least 5 loci** (4q35, 9p24, 13q12, 18q21, 22q13)
Polygeny vs. Pleiotropy

(a) Polygenic trait: many genes contribute to a single effect.

(b) Pleiotropy: one gene has multiple effects.
Pleiotropy in Marfan Syndrome

Mistake making fibrillin-1 -- builds elastic tissue

• thinness
• joint hypermobility
• limb elongation
• lens dislocation
• increased risk of heart disease
Modern Synthesis

• production and redistribution of variation

• Natural selection is one force than can act on this variation to cause change
Evolution = changes in gene frequencies over time
Four Forces of Evolution

- Mutation
- Gene Flow
- Genetic Drift
- Natural Selection
Figure Q-2: Types Of Mutations

A) Chromosomal Mutation

B) Point Mutation

C) Expansion

(A) Chromosomal mutations involve breaks in a chromosome. (B) Point mutations occur when one nitrogenous base is substituted for another - in this case, T becomes G. (C) Expansions occur when the number of copies of a codon is repeated. The expansion shown here involves CAG, just like the expansions in HD. However, expansions in HD can be much larger than the 2 extra copies of CAG shown here.
Mutation

• The only way to introduce new genetic variation

• Very common
  • many neutral
  • many deleterious enough to get removed quickly
  • some are incorporated
Gene Flow

Movement of alleles within and between populations
Genetic Drift

- The random factor
- Greatest effect in small populations
- Founder effect
Genetic Drift - Founder Effect
Clinodactyly

Retinitis pigmentosa
Genetic Drift - Bottleneck

Parent population

Bottleneck (drastic reduction in population)

Surviving individuals

Next generation

The original variation in a population. $V_0$

A few individuals are randomly extracted and start a new population. $V_f$

Founding group

The resulting population has only the variation of the founding group. $V_r$
Natural selection

- differential reproductive success over multiple generations
- some variations are more successful than others, leading to a change in the entire population over time
Natural Selection

![Diagram of Natural Selection]

- Stabilizing selection
- Disruptive selection
- Directional selection

Legend:
- Number of individuals
- Size